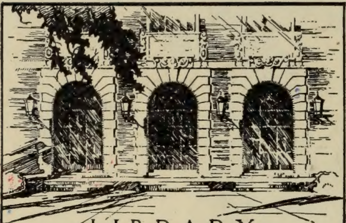

BULLETIN

OF THE

ILLINOIS

State Laboratory of Natural History

(NORMAL, ILLINOIS.)

VOL. I.

Contributions to a Knowledge of the Natural History of Illinois.

1876-1883.

BLOOMINGTON, ILL.:
PANTAGRAPH PRINTING ESTABLISHMENT.
1884.

INTRODUCTION.

The Illinois State Laboratory of Natural History, under whose auspices these bulletins are published, had its origin in 1862, as the museum of the old State Natural History Society of Illinois, and was continued in that relation until 1871, when, with the practical dissolution of the society, the museum was made over to the State. This action was taken in pursuance of an act of the State legislature making the continuance of certain appropriations previously granted in aid of the society contingent upon the transfer of the entire property to the State.

From the time of this transfer the establishment performed the functions of a State Museum of Natural History as far as its limited resources and restricted quarters would permit, until 1877, when it was converted, in accordance with the law establishing a State museum at Springfield, into a natural history laboratory. By this law it was relieved from the necessity of maintaining a display of specimens, and charged with the collection, preservation, and determination of all zoölogical and botanical material for the museum, with the supply to the state educational institutions of the natural history material needed for the proper performance of their work, and to the State Museum of a series of specimens illustrating the botany and zoölogy of the State. By subsequent laws it was made the source of supply of zoölogical specimens to the public high schools, and was charged with the elaborate investigation of various zoölogical and botanical subjects having especial economic or educational relations.

The operations of the laboratory now naturally took on the character of a more thorough and methodical natural history survey of the State than had been previously possible; and with a view to the publication of partial and preliminary reports of the results of this survey, and also for the purpose of giving to active local naturalists the encouragement afforded by a medium of prompt publication, this series of bulletins was begun in 1876.

The first number was issued as the bulletin of the Illinois Museum of Natural History, but the second, and succeeding numbers, as bulletins of the laboratory.

The series has now reached a size and importance which makes it desirable that the plan of their publication be changed for one more systematic and uniform. The six bulletins thus far published are consequently considered to form a single volume, and a new volume has been commenced, which will be paged continuously, and divided, not into "bulletins," but into articles, usually to be issued separately, as fast as ready.

S. A. FORBES, Director.

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ERRATA.

BULLETIN No. 1.

Page 33, line 5, after Report, read 1853 and '4.

Page 34, insert *Genus Poecilichthys, Ag.* between numbers 1 and 2.

Page 38, second line, for 2 1-6 read $2\frac{1}{6}$. Wherever, in this paper, two figures are separated by a hyphen, they should be written in the form of a common fraction.

Page 40, line 11, for *Aphredodereus* read *Aphredoderus*; under No. 40, for *gruuniens* read *grunniens*.

Page 44, No. 71, for *chrysochrous* read *chrysochloris;* for J. N. read J. W.

Page 45, No. 74, for E. L. read F. L.

Page 47, after 103 insert the following:—$103\frac{1}{2}$. *C. analostona, Grd.*, Silver-fin. Everywhere abundant through Central Illinois. Occurs less commonly further north.

Page 52, Note 2, for der read den; for Archiev. read Archiv.
Note 3, for des read der; for Wein read Wien.

Page 53, 8th line, for M. Bary read DeBary.
Note 7, for der (Brandpilze) read die.

Page 54, for *Peronosporiæ* read *Peronosporeæ.*

Page 55, 8th line, for *hauptoria* read *haustoria.*
14th line, insert (12) after six, and add one to each of the three reference numerals following.
5th line from bottom, omit (15).
2d line from bottom, insert (16) after Common.

Page 56, 10th line, 2d paragraph, instead of '75–6 read '74–5.
15th line from bottom, for pappillate read papillate.
11th line from bottom, for *Poltactis* read *Polyactis.*

Page 57, 7th line, for *Peronosporiæ* read *Peronosporeæ.*
21st line from bottom, insert European before vine.

Page 58, 8th line, for *Peronosporiæ Peronosporeæ.*
2d line, 2d paragraph, for 3 read 5.
7th and 8th lines, 2d paragraph, for one to three read twelve to fifteen.
4th line from bottom, for *bignouioides* read *bignonioides.*

Page 68, No. 40, reduce Acridium differentiale, etc., to a synonym, and insert above it C. differentialis, Thos.

Page 72, Plate II, fig. 1, for *Melanispora* read *Melampsora.*

Page 73, Plate III, fig. 3, for 3 read 5.
Plate III, fig. 5, for 5 read 3.
Plate III, fig. 7, for Plycinidia read Pycnidia.
Plate IV, fig. 12, for *fresii* read *friesii.*

BULLETIN No. 3.

In the preparation of the paper on The Food of Birds in this Bulletin, Uhler's "List of Hemiptera West of the Mississippi River" (1876) was followed with respect to the arrangement of the species mentioned; but through an unfortunate misunderstanding of the intention of the author of that list, the Pentatomidæ were all included under the Cydnidæ. For the latter name, the former should consequently be substituted, as follows:

Page 90, line 3 from bottom; page 92, line 11 from bottom; page 94, line 5, and line 5 from bottom; page 105, line 5 from bottom; page 108, line 13 from bottom; page 117, line 9 from bottom; page 126, line 14 from bottom; page 130, line 16; page 131, line 7 from bottom; page 132, line 13; page 138, lines 16 and 24; page 139, line 10; page 141, last line; page 143, line 2; page 145, line 5; page 148, line 12 from bottom.

BULLETIN No. 5.

Page 6. After description following Family PROTEIDÆ read:

Genus NECTURUS, Raf.

3. *N. lateralis*, (Say) Bd. Mud Puppy. Above brownish, with darker subcircular spots; generally a dark stripe from snout back to eyes. A more or less distinct lateral band in young. Below dusky. Large, bushy, bright red gills, forming three tufts on each side of head. Head depressed; snout truncated; gular fold well developed; tail much compressed. $1\frac{1}{2}$ feet. Eastern region, except New England and Eastern Middle States, and from a few points in Austroriparian.

4. *N. punctatus*, (Gibbes) Cope. Above nearly uniform dark olive, with numerous small orange or yellowish dots irregularly distributed over the whole surface, and large, dark, ill-defined spots at distant intervals. No lateral band. Beneath pale flesh color. Smaller and more slender than the preceding species. Eastern S. Carolina.

Page 18. Before FIRMISTERNIA and ARCIFERA, for ORDER read SUB-ORDER.

Page 22. Before RANIFORMIA, for ORDER read SUB-ORDER.

BULLETIN No. 6.

Page 6, line 12 from bottom; page 8, line 15; page 11, line 2; for *Cydnidæ* read *Pentatomidæ*.

Page 17, line 9, before *Vireo* omit *and*.

Page 23, above Arachnida, for *Cydnidæ* read *Pentatomidæ*.

Pages 25 and 27, above *Orthoptera*, for *Cydnidæ* read *Pentatomidæ*.

Page 28, lines 2 and 8, for *Graphorhinus vadosus* read *Epicærus imbricatus*.

Page 64, under *Hemiptera*, for *Siphonophora granariæ* read *Aphis maidis*.

Page 69, line 5 from bottom, for *fresh-water* read *local*.

Page 78, line 1, after *all* insert *the*.

Page 82, line 7, for *character* read *characters*.

Page 91, line 5, for *consisted* read *consists*.

Page 92, line 2 from bottom, for *more* read *most*.

Page 97, line 11, for *fory-six* read *forty-six*.

Page 99, line 2, for *witn* read *with*.

Page 101, lines 12 and 13 from bottom, for *structure* read *structures*.

Page 105, line 23, for *aération* read *aëration*.

INDEX.

In the following index, the numbers of the bulletins are indicated by Roman numerals, and the pages by Arabic.

Where reference is made to an item relating to *the food* of a species or other group, an asterisk (*) has been placed after the page number; a dagger (†) has been used to indicate that the object *has been eaten.*

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INTRODUCTION.

AT the semi-annual meeting of the Board of Education of the State of Illinois, held at Normal, Ill., on the 15th of December, 1875, the following preamble and resolutions were unanimously adopted :

WHEREAS, Since the control of the Museum of the Illinois State Natural History Society was transferred to the State Board of Education, no general declaration has ever been made by this Board of the relations and policy of the Museum, or of the purposes of the Board concerning it; and

WHEREAS, It seems desirable that the students and friends of science should know definitely and authoritatively the nature, scope and promise of the work of said Museum, in order that they may intelligently co-operate with its officers for the promotion of the scientific interests of the state ; therefore,

Resolved, That we regard the Museum as a State Institution, devoted to the prosecution of a natural history survey of the state, to the encouragement and aid of original research, and to the diffusion of scientific knowledge and habits of thought among the people.

That we consider it an important part of its work to supply collections of specimens to the public schools, as far as this can be done consistently with its own general interests, and especially to provide all needed facilities for the instruction of teachers in natural history, and in the most approved and successful methods of teaching the same; and

That we cordially invite the co-operation of the scientists of Illinois, offering them the free use of its collections, library and apparatus, and assuring them that whatever may be contributed to its cabinets or its funds shall be used faithfully and impartially for the advancement of science throughout the state at large.

In pursuance of the first of the above resolutions, the issue of a series of publications has been undertaken, which it is intended to devote especially to the natural history of Illinois. These bulletins will contain original contributions to a knowledge of any department of the natural history of the state ; such compilations, synopses, and the like, as will bring together widely dispersed and virtually inaccessible published matter relating to the local natural history, placing it in manageable form, within reach of the ordinary student ; and papers of value on economical science.

Within these limits it is desired that the publication may be made the

organ of all Illinois naturalists, upon whose active aid the success, and especially the degree of usefulness, of the enterprise is, of course, almost entirely dependent.

It is believed that by thus limiting the undertaking to a special field in which our own naturalists may be supposed to be better able to work than any others, and to which they are more likely to devote themselves with ardor and success, all the advantages of a local stimulus to research may be gained without inflicting upon science any increase of the number of rival centers of publication of similar scope and purpose.

For the purpose of providing better facilities than now exist for the future prosecution of the work here outlined, it is necessary that complete collections of specimens should be made in all parts of the state, that a full and well-selected library should be brought together, and that these should be thoroughly organized for practical use. Contributions of specimens and books are therefore earnestly desired. These will be received at the Museum, properly cared for, promptly arranged, catalogued and indexed, and held for the use of any working naturalist.

S. A. FORBES,

Curator Illinois Museum of Natural History.

NORMAL, ILL., Oct. 16, 1876.

BULLETIN

OF THE

ILLINOIS MUSEUM OF NATURAL HISTORY.

NUMBER I.

LIST OF ILLINOIS CRUSTACEA,

WITH DESCRIPTIONS OF NEW SPECIES.

By S. A. FORBES.

The following list is to be regarded as only a first contribution to the knowledge of our crustacea, as it presents the results of a single season's work. Considering the fact that, while our streams and pools are populous with interesting forms, many of which are new, only a single species outside the genus *Cambarus* has heretofore been credited to the state, it is hoped that even so imperfect a paper as this may not be without its uses.

I wish to acknowledge especial obligations to Professors A. E. Verrill and S. I. Smith of Yale College for specimens and for suggestions concerning the species of *Eubranchipus* and *Crangonyx* described herein, and to the latter of these gentlemen for many other favors.

Cambarus acutus, *Gir*. Very common in central Illinois. Taken in large numbers at Normal and Pekin. Of 25 males examined, the first abdominal legs were all those of Hagen's variety A. In none was the epistoma pointed, and a distinct lateral thoracic spine was present in but one. In twenty of the specimens the margins of the rostrum were distinctly convex from the base to the apical teeth; and the latter were in all much smaller than in Hagen's figures, the distance across the teeth being but one-fourth to one-third that across the base of the rostrum between the tips of the spurs. The tubercle in the basal foveola was elongated, notched in front and continued backward into a very slight cephalo-thoracic carina. Between the posterior callosities and the transverse line, the cephalo-thorax was finely rugulose. The females observed were also variety A.

C. stygius, *Bundy*. "Male. Rostrum long, triangular, smooth above, small teeth near apex, foveolate at base; carinæ parallel, separated from base of rostrum by slight grooves; cephalo-thorax somewhat compressed, smooth or slightly punctate above, granulate on sides, areola narrow, smooth;

antennal plates wide, truncate at apex, apical teeth short; epistoma rounded in front, twice as wide as long; third maxillipedes hairy on inner sides, hands short, smooth above, serrate on inner margin, fingers short, straight, ribbed and punctate above, contiguous margins tuberculate, outer one hairy; third and fourth joints of third thoracic legs hooked; first abdominal legs short, truncate, enlarged towards apex, apical part recurved, then ending in three obtuse points turning outward, leaving a wide groove passing up on outer side behind teeth. The female has ventral ring flat, with posterior margin slightly elevated. Lake Michigan; washed up during a violent storm." (*W. T. Bundy.*)

C. troglodytes, *Lec.* This species I have not yet taken. It is mentioned here on the authority of Dr. Hagen.

C. virilis, *Hagen.* A few specimens have been collected at Normal, Cairo and Pekin, Ills., all young or of the second form except one male from Normal, which belongs to Hagen's variety A. The thorax is, however, broader and smoother, and the areola wider than in the typical form, which has been received from Rock river, Wis.

C. wisconsinensis, *Bundy.* "Male. Rostrum wide, narrower in front, straight, nearly plane above, foveolate at base, anterior teeth small, acumen short, acute; cephalo-thorax cylindrical, punctate, anterior margin not angulated, lateral tooth obtuse; dorsal area rather narrow, indistinctly defined; antennal plates longer than rostrum, greatest width in apical half; antennae slender, reaching to middle of abdomen; epistoma as wide as long, truncate in front; maxillipedes hairy on inner side and below at base; third joint of third legs hooked; first abdominal legs long, bifid, nearly straight, exterior part longer, tips slightly recurved; tips of interior parts recurved, acute, swollen near apex. Normal, Ill., and Racine, Wis.." (*W. T. Bundy.*)

C. placidus, *Hagen.* "Quincy, Ill.," (Hagen.) I have not seen this species.

C. propinquus, *Gir.* Not common. Taken at Normal, Pekin and Freeport.

C. immunis, Hagen. This is the commonest species of central Illinois. It is especially frequent in the muddy ponds of the prairies, whence it may be drawn by the hundred with a small seine.

The general form of the rostrum of the young is the same as that of the adult; but more or less evident ante-apical teeth are present. The abdominal legs of the second form of the male are much thicker at the tip. In the first form the branches are slender and distinct throughout the distal half of their length, the outer branch is compressed at tip, and the inner depressed and widened a little, and channeled on the anterior surface. In the second form both branches are equally thick and strong, neither is compressed or channeled, and the two do not separate except at their tips after making the backward turn. The sudden thickening of the leg at its posterior middle is much less evident in the second form.

About one-fourth or one-half the specimens taken from stagnant ponds in midsummer are more or less completely covered above by the eggs of a species of *Corixa*,—probably *C. alternata*, *Say*, since this is much the

commoner of the two species found in such situations, the other being as yet undescribed.*

These eggs are attached as closely as they can be placed, by the end opposite the micropyle, and do not seem especially to inconvenience their bearers.

The point of attachment preferred is the margin of the abdomen, out of the way of the legs: but the eggs are gradually extended along the sides of the cephalo-thorax until sometimes the body is almost entirely covered. A careful search of the weeds and other submerged objects in the ponds discovered no other place of deposit of these eggs. As these ponds usually go dry during the summer, it seems not unlikely that the Corixa may attach its eggs to the crawfish in order that the latter may, in such an event, carry them to other waters. It is not to be supposed, however, that the Corixa is entirely dependent on the crawfish for the preservation of its progeny, for the parent can fly, and is occasionally taken on the wing; nevertheless, this curious expedient must prevent a great waste of eggs, and so operate to the advantage of the species. But the subject requires further study.

C. obesus, *Hagen*. Very common. The largest in the state.

C. gracilis, *Bundy*.* "Rostrum short, wide, depressed, concave above, acumen short; cephalo-thorax compressed, areola none, the pleura meeting on median line of dorsum, posterior spatium much wider than anterior; chelae long; inner margin tuberculate-serrate, fingers slender toward apex, outer one with strong tubercle on inner margin near base, movable finger with strong tubercle near middle of inner margin; carpus long, strongly toothed on inner, and lower front margins; third maxillipedes hairy on inner sides; third joint of third thoracic legs hooked; first abdominal legs of male truncate, with several small apical teeth, of which the inner one is much longest, slender and pointed outward, base of these legs inserted in deep sinuses in the strongly developed ventral part of first abdominal segment. Ventral ring of female movable; longitudinal fissure widest behind." (*W. T. Bundy.*) Very common along water courses in early spring. It was first detected by Prof. Bundy, in the museum collections, in the autumn of 1875, has since been taken in great numbers at Normal, and has been received by Prof. Bundy, from Racine, Wis.

Palaemon ohionis, *Smith*. Abundant at Cairo, where it is frequently eaten. Smaller specimens were taken in the Mississippi near Grand Tower, in Jackson county, and it is reported by boatmen to occur from St. Louis to New Orleans, growing larger towards the south. It has not yet been found in the Illinois River.

Palaemonetes exilipes, *Stimp*. Very common in the Illinois River, where it seems to be the only shrimp. Taken in large numbers at Pekin.

Hyalella dentata, *Smith*. Occurs in myriads in the swamps of the Calumet river, at South Chicago, and sparingly in Rock river, at Oregon, Ogle county. Not seen further south.

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*Uhler.

*The descriptions quoted have been kindly furnished me by the discoverer of the species.

Gammarus fasciatus, *Say*. Apparently occurs throughout the state, in small rocky streams. Collected at Deer Park, La Salle county, in a small branch of the Vermilion, and in several streams in Jackson and Union counties. Scores of males and females were taken together under stones, on the 30th of July.

In specimens from southern Illinois, the hands of the first pair in both sexes bear stout spines on the distal half of the posterior margin in addition to those on palm and at the tip of dactyl. A short transverse row of long hairs is situated at the base of the median palmar spine. The inner side of the hand of the second pair in the male is ornamented with two longitudinal series of short transverse rows of hairs,—the posterior of five rows, the anterior of three. The palmar margin in the female has the lamellar edge. The lateral clusters of spines on the fourth posterior abdominal segment, in both sexes, each contain one very stout spine and several slender ones, while the median cluster consists of slender spines only. Each of the clusters on the fifth and sixth segments consists of two stout spines and several slender ones, except the median fascicle of the sixth segment, which consists of two distinct clusters of slender spines. The divisions of the telson have two clusters of hairs on the upper surface near the outer margin, of which the basal contains two spines. The spiny tips of the divisions are emarginate.

Crangonyx gracilis, *Smith*. Very common in central Illinois. Collected at Bloomington, from slow,shallow streams. These specimens differed in several small details from those described by Prof. Smith, the most important relating to the caudal stylets. In the typical form the tips of the three pairs are even ; but in the Bloomington specimens the second pair extends farther back than the third, and the first farther than the second. The inner ramus of the last pair is sometimes unarmed, but oftener bears one or two spines at or near the tip. The length of ovigerous females is 10 mm. ; of the largest males observed 8½ mm.

A form from southern Illinois represented in my collections by a few females, I cannot distinguish specifically from the above, although the second hands are proportionally longer and narrower and much more spiny, the anterior and posterior margins less convex, and the palmar margin more so. The tips of the caudal stylets reach the same perpendicular plane, and the inner ramus of the last is always as long as the width of the outer and bears one or two spines.

Crangonyx mucronatus, *Forbes*. This remarkable species is perhaps entitled to rank as the type of a new genus ; but, until I have the material for a more general study of its relations than I am able to make at present, I prefer to place it with its nearest allies in the genus *Crangonyx*.

Colorless, blind; *length* 9 to 10 mm, *width* 1 mm. The *head* is a little longer than the first thoracic segment, its anterior margin concave at the bases of the upper antennae, convex between them ; the posterior margin straight in the middle and curving forward on the sides. The front angles of the first *thoracic segment* are uncovered and produced a little forward ; the hind angles of the first five segments are rounded and produced strongly backward. The first three *abdominal segments* have the lateral

margins and all the angles broadly rounded, and the posterior angles, as well as the posterior margin of the seventh epimeron, are slightly notched and bristled. The *upper antennæ* of the male are two-thirds to four-fifths as long as the body. The first and second joints of the pedicel are sub-equal, each about as long as the four basal joints of the flagellum ; the third is one-third as long as the second. The flagellum is about five times the length of the pedicel, and is composed of 30 to 35 joints, each with a few short hairs at tip, and all except the seven or eight basal joints and the last with a slender olfactory club. The secondary flagellum contains two bristled joints, together a little longer than the first of the primary flagellum. Pedicel of *lower antennæ* longer than that of upper, the last two joints equal, each a little longer than basal joints of upper antenna. Flagellum nine or ten jointed, without olfactory clubs. Right *mandible* with dental laminae equal, each with five conical, obtuse, sub-equal teeth. The anterior lamina of the left mandible is much the larger and stronger, with three very strong, blunt teeth; posterior lamina with three slender and acute teeth. *Palpus* three-jointed ; basal quadrate, about half as long as second, which is clavate and nearly twice as wide as long, with about ten long hairs on its rounded hind margin which are longest and closest distally. Last joint a little longer and narrower than second, regularly convex in front, straight on proximal half of hind margin, slightly concave on distal half, and fringed here with about 24 slender hairs, the three or four at tip becoming suddenly very much longer. A few scattered hairs on front margin of this joint.

Inner plate of anterior *maxilla* is nearly hemispherical, about half as long as outer, with four plumose hairs on the rounded margin, which are about as long as the plate itself. *Palpus* two-jointed, first quadrate, one-third as long as second, which is oval, pointed, tipped with two claws and some smaller spines. Laminae of basal joints of *maxillipeds* short, neither pair extending beyond tips of succeeding joints.

First two pairs of feet equal. Dactyl of first pair in male curved, two-thirds as long as *hand*. The latter is broad-ovate, two-thirds as wide as long, the palmar and posterior margins forming a wide angle. Long hairs on posterior surface in transverse rows. Palm with about fifteen short, notched spines, each with a hair arising from the notch. Carpus sub-triangular, three-fourths as wide as propodus, hind margin very short, with one or two pectinate spines and a few long hairs. Second pair similar, propodus a little longer and narrower; carpus as wide as propodus, posterior margin longer, with about five transverse rows of long bristles, of which the distal row are doubly pectinate on terminal third. The three posterior pairs of *thoracic legs* increase in size backwards, the first of these being not quite two-thirds as long as the last. The seventh epimeron is narrow, with the lower margin regularly arcuate. The tips of the first pair of *anal legs* extend beyond the tips of the second, and these beyond the tips of the third. The latter are therefore very short, about as long as the pedicel of the second pair. The outer ramus is ovate, truncate, half as long as the pedicel, and hairy at tip; the inner is an unarmed rudiment, one-fourth or one-fifth the length of the outer. The *telson* of the male is a smooth cylindrical

appendage, usually about as long as the first three abdominal segments, and as large as the last joint of the pedicel of the lower antenna. It presents a very slight double curve, is obliquely rounded at the end and tipped by a cluster of short hairs. In some cases this appendage is half as long as the body.

The female differs in the following particulars. The upper antennae are only about half the length of the body, the flagellum not more than three times as long as the pedicel, and the secondary flagellum is usually a little shorter. The propodus of the *first pair of feet* is similar in outline, but the palmar margin and dactyl are shorter and the posterior margin longer. The *second pair* are extremely like the second of the male, but are decidedly smaller than the first. The *telson* affords a difference so remarkable that the two sexes, at first sight, would hardly be referred to the same genus. In the female this is very similar to the telson of *C. gracilis*, *Sm.* It is flattened and slightly emarginate, a little longer than broad, extending to the tips of the second pair of anal legs, and bears two terminal clusters of spines of four or five each.

This species was first discovered by me in a well at Normal, Ill., during the summer of 1875. It was subsequently found by Mr. Harry Garman in great numbers in springs, and even at the mouths of drains, after a long period of heavy rains. With the advent of dry weather it entirely disappeared from these, but still occurs sparingly in wells.

Asellus brevicauda, *Forbes.* Length without caudal stylets, 10 mm. to 15 mm.; width, 3 mm. to 5 mm. Color as in *A communis.* Head a little longer than first thoracic segment and about two-thirds as wide; anterior margin distinctly concave in middle and retreating each side, anterior angles distinct, sides straight, nearly parallel on anterior three-fourths.

The posterior fourth is produced on each side into a prominent lateral lobe bearing several stout spines. The distance to which this lobe projects equals half the length of the lateral margin of the head in front of it. The *eyes* are rather small but prominent, and are situated just within the middle of the straight portion of the lateral margin. The re-entering angle at the side of the head is a little less than a right angle, but its apex is rounded. The *thoracic segments* are sub-equal in length, of the usual shape, but becoming very concave behind. The concavity of the last segment amounts to more than half the length of the segment. The anterior angles of the first segment are deeply emarginate, the notch being nearly filled by the epimeron; but there are no other lateral emarginations in any of the segments, nor are any other epimera visible from above. In some young specimens the lateral margins of the two or three posterior thoracic segments are slightly sinuate. The hind angles are all rounded, and the free margins are all beset with long bristles, longest on the lateral margins and especially at the angles.

A short first *abdominal segment* is visible in the concavity of the last thoracic. The last abdominal is wider than long, with a broad rounded projection occupying the median half or two-thirds of the posterior margin, reaching half way or more to tips of pedicels of caudal stylets. The pos-

terior lateral angles are distinct though obtuse, the hind margin being somewhat concave each side the median lobe ; and the margins are hairy as in the thorax.

The *upper antennae* are nearly as long as the pedicel of the lower. The flagellum consists of 11 to 13 joints, the two terminal together about as long as the preceding one. The three joints preceding the last bear, each at its anterior internal angle, a large olfactory club about at long as the eighth joint of the flagellum.

The *lower antennae* extend backward about to the base of the abdomen. The last joint of the pedicel is as long as the two preceding. The flagellum contains about 60 joints in the female and 90 in the male.

The *palpus of the mandible* is small, three-jointed, the first joint clavate, with three spines on the distal half of the posterior margin and one or two at tip. The second joint is about twice as long as wide, slightly concave in front and with a distinct median angle behind. There are two or three scattered hairs on the basal half of the posterior margin, and many long plumose hairs, shortening distally, on the terminal half. The third joint is ovoid, tapering, very broadly rounded in front and distinctly concave behind. The concave posterior margin bears a row of long plumose hairs, regularly lengthening toward the tip, and a sub-marginal row of shorter hairs on the side of the joint. The basal joint of the *palpus of the maxilliped* is very short, transverse, about thrice as broad as long, with outer margin perpendicular to terminal. The second joint is a little broader than long, rounded slightly without, very broadly within, and plentifully ciliate on both edges.

The third joint is about two-thirds as long as second, broadly and regularly rounded within, narrowed about one-third at tip ; the fourth clavate, incurved, as long as second, at tip about half as wide as long ; the fifth about half as wide and long as fourth, incurved, obtuse. All the joints bear long marginal hairs.

The *first pair of feet* in the male are strongly sub-chelate ; the propodus a little more than two-thirds as wide as long, the palmar margin straight, with one strong tooth at base and another at middle. The posterior margin is only about one-fifth the palmar, and perpendicular to it. The dactyl is strong, curved, serrate behind with about seven distinct teeth. The terminal claw is strong, acute and curved. Both margins of the propodus and the front of the dactyl are hairy : a cluster of longer hairs is seen near base of claw of dactyl.

The propodus of the female is a little narrower and the palmar margin is somewhat concave. The tooth at the middle of the palmar margin is smaller, but quite distinct.

The *basal abdominal plate* beneath in the female is obtusely triangular, about half as long as the basal part of the next plate behind. The first pair of *genital plates* in the male are long and narrow, the terminal joint truncate, strongly excurved beyond the middle, and bordered posteriorly by about six long bristles a third as long as the joint.

In the second pair of plates the basal joint (pedicel) is twice as long as

the rami and three-fifths as wide as long. The second joint of the outer ramus is ovate and twice the length of the first. The inner ramus reaches to the middle of this joint, is broader than in *A. communis,* but of similar shape, and indistinctly bifid at tip.

The *opercular plates* do not reach the tip of the abdomen, but are obliquely truncate, their posterior margins forming a wide re-entering angle. The *anal stylets* are very short, flat and broad. The peduncle is ob-triangular, nearly as broad as long, the tip oblique, the inner edge being the longer and somewhat rounded. The outer ramus is narrow-ovate, obtuse, as long as the peduncle, and seven-eighths the length of the outer ramus. This is also ovate and obtuse, the outer margin nearly straight, the inner convex. All the joints bear many marginal spines, longest at tips of rami.

This species was found in clear, rocky rills in Jackson and Union counties in Southern Illinois.

Asellus intermedius, Forbes. This species is more closely allied to *A communis* than to *A. brevicauda*, but, as will be seen from the description, stands between these two. Its *length*, in adult females, is but 6 mm., its *breadth* about 2 mm. The sides of the *head* diverge posteriorly, and the lateral lobe is smaller than in *brevicauda*, bearing a single spine and a few short hairs. The first *thoracic segment* is narrowed anteriorly, showing the epimera, but is not emarginate. The others are distinctly emarginate on the sides, the emarginations moving gradually backwards, in the succeeding segments, from the anterior to the posterior angles. The free margins of all the segments are strongly spined. The lobe of the hind margin of the *abdomen* is shorter and broader than in *brevicauda*, reaching laterally to the middle of base of each caudal stylet, and extending backward to the middle of length of pedicel. The posterior angles of the abdomen are regularly rounded and indistinct.

The flagellum of the *upper antenna* is nine-jointed, the first joint short, about half as long as fourth.

The *first pair of feet* of the male are stout, the hand two-thirds as wide as long, the palmar margin straight, with a slender tooth at base and a strong conical one at middle. The posterior margin of the propodus is very short, about one-sixth the palmar, the dactyl long and strong, the tip of the claw when closed reaching beyond the base of the hand. The posterior margin of the dactyl is serrate with appressed teeth as in *brevicauda*. The carpus is triangular, the posterior margin straight and usually armed with a strong blunt spine at its distal fifth. The hand of the female is narrower and smaller, its breadth being about half its length. The palm is straight and shorter than in the male, the posterior margin longer, (nearly half the palmar), the two margins forming a wide angle. The spine at this angle is slender, and there is no trace of a tooth on the palmar margin, or on the carpus.

The first pair of *genital plates* in the male are short and broad, the basal joint scarcely longer than wide, the second joint elliptical, broadly rounded at tip and convex both sides, fringed posteriorly and on posterior half of outer margin by a few short hairs. The pedicel of the

second pair is about as long as wide, the rami are as long as the pedicel and sub-equal. The second joint of the outer ramus is elliptical and thrice as long as the first. The inner ramus is nearly half as wide as long, the basal processes obtuse and low, the outer one being almost obsolete. The outer terminal angle is prolonged into an incurved process, the inner provided with a movable (?) excurved claw.

The *caudal stylets* are flat and broad, but narrower than in *brevicauda*, about three-fifths as long as the abdomen. The width of the pedicel is two-thirds its length. The outer ramus is nearly five-sixths the inner and equal to pedicel. Both rami are narrow-ovate, and very obtuse, the inner about four times as long as wide and nearly straight on the outer margin. Both pedicel and rami are spiny on their margins, and the latter are tipped with a few long hairs.

Abundant in the hill-country of southern Illinois, under stones in small streams.

While these two species of Asellus were found in considerable numbers on the first day of my trip, I have never seen a specimen of either in the central or northern part of the state, although I have carefully searched the most varied situations.

Asellus stygius, *Packard*. This species has been peculiarly unfortunate. Described originally from an injured specimen, its structure and relations were misunderstood and it was made the type of a new genus, (*Caecidotea*, Packard). It was soon re-described by Prof. Cope, under the specific name *microcephalus*; and these imperfect descriptions have since been supplemented by several fragmentary notices in various papers by Packard and Smith.

With a view to giving a more coherent account of it, I have examined many specimens of both sexes and various ages, and have prepared the following description: A detailed comparison of this species with undoubted *Asellus*—especially with the admirable plates of *A. aquaticus* in the *Crustaces d' eau douce de Norvege*, has failed to reveal any structural peculiarities which could possibly serve as the characters of a distinct genus, and I have therefore united it to *Asellus.*

Colorless, blind, narrow, very loosely articulated, sides nearly parallel, 12 to 14 mm. by 2 to 3 mm.

The *head* is a little narrower and longer than the first thoracic segment, narrower in front than behind, with the front margin concave, the front angles rounded, the hind margin nearly straight. It is a little constricted behind the mandibles. The first *thoracic segment* is narrowed a little to the front so as to show the epimera, the sixth and seventh are also much narrower before than behind, and longer than the others. The front angles of the second and third segments are obliquely truncate, the hind angles broadly rounded. All the segments behind the first are slightly emarginate on the sides, the emarginations being carried gradually backward to the posterior angles. The anterior margins of the segments change gradually from concave to convex, and the posterior margins from sinuate to deeply concave. The head and all the segments are slightly pubescent above and bor-

dered laterally with short hairs. The large *abdominal segment* is preceded by two very short ones. The abdomen is about as long as the last two thoracic segments, the hind angles rounded but distinct, the hind margin very slightly sinuate.

The *upper antennae* reach to the tip of the penultimate joint of the pedicel of the lower. Pedicel and flagellum about equal, latter ten to twelve-jointed, bearing a slender olfactory club at tip of each of the four or five joints preceding the last. Joints of pedicel sub-equal in length, but the first twice as large as the second.

The *lower antennae* are about two-thirds as long as the body in the female, in the male somewhat longer. Pedicel about one-third flagellum, five-jointed, fifth and sixth joints each longer than the basal three together. The flagellum contains 75 to 80 joints. The *mandibles* are almost exactly as in *Asellus aquaticus*. The posterior dental plate of the left mandible is nearly as wide as the anterior. The hairs of the marginal fringe are more numerous on the right mandible than on the left, and the anterior eight are toothed instead of plumose.

The *mandibular palpus* is slender, the basal joint a little shorter than the second. On the latter the external angulation is considerably behind the middle. The distal joint is narrow, lunate, (distinctly concave on outer margin) about five-sixths the length of the preceding joint, with about 20, jointed, plumose, marginal hairs, similar to those on the distal half of outer margin of preceding joint. The two plates composing each *mauilla* of the *first pair* are equal in length. The inner is three-fourths as wide as the outer, terminating in five plumose hairs. The outer terminates in twelve strong spines, of which the five outer are stronger and simple, and the seven inner irregularly and bluntly toothed near their tips. The *posterior maxillae* as in *Asellus aquaticus*. The shorter internal hairs on the two outer plates are expanded transversely to the plane of the plate and hollowed lengthwise on the inner face, giving each hair the form of a racing-shell, while both edges of the hair are coarsely toothed. The basal joint of the *palpus of the maxilliped* is quadrate, the fourth joint is about as long as the second and third together. The inner margins of the fourth and fifth are provided with very long hairs. The flagellum (*fouet*, Sars.) is as broad as long, with about eight scattered hairs at tip and several shorter ones on external margin.

The propodus of the *first pair of feet* in the male is very large, broad-oval, two-thirds as wide as long. A strong curved spine is situated at the proximal end of the palm, and two truncate, stout teeth separated by a rounded emargination, near the distal end. The dactyl is strongly curved, especially at base, its inner edge serrate with six acute teeth appressed towards tip. The length of the terminal claw is more than one-third that of the entire dactyl. The convex margin of the dactyl bears a few scattered hairs, and a cluster of four or five near the tip. The carpus is small as in *A. aquaticus*, and spined on its distal margin. The female hand is smaller and narrower, (width to length as 1 to 1¼) the palmar margin concave, the pair of truncate teeth replaced by a single smaller conical one which is sometimes obsolete. The other differences are trivial. The *legs* become longer

behind, the tip of the second pair reaching as far as the base of the propodus of the seventh. The *abdominal sexual plates* of the male are in two pairs, as usual. (See plate). The corresponding plates of the female are but one pair, rather narrowly ovate, ciliated at tip and on posterior two-thirds of outer margin, with a few short spines at the base of the inner edge. The external ramus of the next pair—serving as a gill-cover—bears a terminal fringe of plumose hairs and a few short spines at base on outer margin. The inner ramus—first gill—is oblong, two-thirds the length and breadth of the outer. Both the pedicel and rami of the *caudal stylets* are slender and cylindrical, the former about as long as the last two joints of the last pair of legs, the latter tipped each with a cluster of bristles, the inner about two-thirds as long as the pedicel, the outer varying from one-quarter to two-thirds the inner. The length of the rami varies greatly with age and sex. In many old males the inner is very long and the outer minute. There are four pairs of *incubatory lamellae* in the female, each pair overlapping by their rounded inner ends, except the first, which are shorter and have the anterior internal angles emarginate.

The description has been given above in greater detail than would otherwise have been necessary, in order to settle the question of genus. The species is found quite frequently in deep wells of central Illinois, in company with, but much more abundant than, *Crangonyx mucronatus.*

After a long period of heavy rains during the last summer had greatly swelled the subterranean streams which these species inhabit, they appeared at the surface in springs, and even at the mouths of tile drains, in such numbers that a hundred could be taken in an hour. A few females were observed with eggs at this time. (July).

Eubranchipus serratus, *Forbes.* This species seems to replace the *E. vernalis*, *Verrill*, of the Eastern States, to which it is closely allied. An important character, constant in the large number of both sexes which I have examined, is found in the *abdominal segments*, which are narrowed in front, with rounded anterior angles, while the posterior angles are produced backward, giving a decidedly serrate appearance to the abdominal margin. The last two abdominal segments are closely united and broader than the preceding.

The *antennae* extend a little beyond the eyes, and terminate in a cluster of about five slender olfactory clubs. The *frontal appendages* of the male are considerably longer than the claspers, to the front inner base of which they are attached, the line of attachment being parallel to the length of the basal joint. Their form is irregularly oval, the inner edge being regularly convex on its distal three-fourths and the outer sinuate—convex on basal two-thirds, and slightly concave on terminal third. Both margins are pectinate, except near base, with thick blunt teeth, which are longest on the basal half of the outer margin, where they are as long as the undivided part of the appendage is wide. At the middle of this margin the teeth become suddenly shorter. On the inner margin they are longest near the middle, regularly lessening towards each end. The under (posterior) surface of the appendage, as well as the teeth, is set with short spines, each springing from an inflated

base. The *claspers* of the male are shorter and stouter than in *E. vernalis.* The basal joint is soft and inflated and bears a corneous rounded tubercle at its inner base.* The second joint is stout and regularly incurved, strongly angulated at its base in front where it is received into the first joint. A long strong tooth, about half as long as the joint, extends backward and a little inward from near its base. The rounded tip of this tooth is thickly set with minute, low, circular elevations, each with a central depression, within which is a disk-like elevation, the whole having the appearance of a minute sucking disk. The tip of the clasper is expanded and flattened within so that the inner (anterior) part has a spatulate form, while the opposite surface rises into a thick prominent ridge, giving to a transverse section of the tip the form of the letter T. The *anal appendages* are linear-lanceolate, as long as the last four segments of the abdomen, and plumosely haired to the base. The ovisac of thefemale is as broad as long, three lobed behind with the middle lobe the largest.

Length of a full grown male, including anal stylets, 20 mm., width 6 mm., across eyes 4 mm., clasper 4.5 mm., frontal appendage 5 mm. by 3 mm. The largest females were a little more slender than the males. This species was first observed at Normal, Ill., in clear pools, in April, 1876. About a fortnight afterward it entirely disappeared. Another species has been sent me by Prof. Bundy, by whom it was taken in Wisconsin.

Canthocamptus illinoisensis, Forbes. Length 1 mm., color light red. Head and first segment united ; five abdominal segments in male, four in female. The suture between the first and second segments is not wholly obliterated above in the female.

Last abdominal segment is deeply and acutely emarginate. Branches of *furca* as wide as long, inner bristle plumose, a little longer than abdomen; outer plumose only on outer side, about half the length of the inner. The second to fifth *abdominal segments* have each a row of spinules along ventral portion of posterior margin.

Male with *anterior antennae* composed of seven joints, the fourth joint very short. The front outer angle of the third is produced, the blnnt process bearing three long bristles surrounding a slender olfactory club which is as long as the three following joints. The penultimate joint bears a strong spine or slender appressed process at the middle of its posterior margin. The five outer joints constitute the grasping organ. The *posterior antennae* bear five long bristles at tip, three of which are made prehensile by the occurrence of from eight to twelve short articulations in the middle of the hair, allowing it to be bent forward. At the base of these articulations on the outer bristle, are two short spinules. Two nearly longitudinal rows of five or six strong, short spines each appear on the under surface of the outer joint of the antennule. The secondary flagellum, borne as usual on the middle of the basal joint, is not articulated, and bears four long bristles, two terminal and two on distal half of inner side. The outline of the *mandible* is exactly like that figured by Claus, but it bears about ten teeth, the upper thick and blunt, the inner sharp, slender and longer. Several are notched

*Wanting in *vernalis*

at tip. The lower angle bears a long simple bristle. *Mandibular palpus* two-jointed, second joint with three long terminal hairs and a shorter spine attached at basal third of anterior margin, jointed at base and directed towards tip of joint, like a dactyl. The *maxilla* and *maxillary palpus* are scarcely to be distinguished from those of *C. staphylinus.*

The first maxillipeds are three lobed, the outer lobe constituting a long, strong claw. The second and third are about one-third as long as the first, and bear each one strong simple spine and one weak branched hair. The inner lobe is widest, about two-thirds as wide as long. The dactyl of the *posterior maxilliped* is spinous on its inner edge, and the same edge of the hand is ciliate and bears a short, stout, sparingly plumose bristle at its base, just beyond the tip of the closed dactyl. The width of this joint (the second) is nearly half its length.

Basal joint of inner ramus of *first pair of legs* nearly or quite as long as outer ramus, the second wider but only half as long as the third, and obliquely truncate. Inner ramus of *third pair of legs* in male is three-jointed, the outer two-jointed, chelate. The finger is ovate, truncate, terminating in two long plumose hairs. The dactyl is linear, curved at base, and twice as long as finger. The inner ramus of the *fourth pair of legs* is about half as long as outer, two-jointed, basal joint short, terminal joint about as long as middle joint of outer ramus. The *fifth pair of legs* is best developed in the female. In the male the length is not over one-third the width. The basal portion bears three plumose hairs on its very broadly rounded anterior margin, of which the innermost is longest. The outer plate is nearly orbicular and bears five spines on its terminal margin, of which the second from the internal angle is the longest. *Genital plates* found in male at posterior border of first abdominal segment, beneath, are short, slightly expanded internally, with internal angles rounded, and externally bear three sub-equal bristles, jointed at base, the inner largest and strongest and semi-plumose. The *antennae* of the female are eight-jointed, extending backward to the first free segment. The basal joint of the *fifth pair of legs* is sub-elliptical in outline, with the basal half produced externally into a broad, triangular process which bears the second joint on its posterior margin. The free end of the basal joint bears six large plumose bristles of which the inner is longest. The greatest width of the joint is nearly equal to its greatest length. The second or outer joint is ovate, sub-truncate, spined on each margin, and bears four plumose bristles at tip and one at the middle of its outer margin. Its length is about twice its breadth. Same habitat as the following :

Diaptomus sanguineus, *Forbes.* This species differs in some slight respects from the genus to which I have assigned it, as characterized by Claus, (*Die Frei Lebenden Copepoden*) but not sufficiently to constitute it a new genus. In the male the fifteenth to eighteenth joints of the right antenna are thickened, the teeth of the mandible are not at all emarginate, the first joint of the terminal portion of the lower maxilliped is smaller than the others, and the right foot of the fifth pair in the male wants the inner ramus, which is perhaps represented by an immovable blunt spine at the

inner inferior angle of the second joint. The *body* of this species is broader than in *D. castor*, the color is throughout a deep red. The *antennae* are nearly as long as the body, the eighteenth joint in the female reaching to the base of the abdomen. The second tooth of the *mandible* is larger than any of the remaining six of the series, and is separated from the third by an interval equal to the width of the tooth. A short feathered bristle appears at the lower end of the row of teeth. The secondary appendage of the *mandibular palpus* is four-jointed, and bears six bristles at its tip and inner margin. The *maxilla* has the normal structure, the basal plate, the two cylindrical processes and the outer ramus (flabellum) and the inner ramus being all present and symmetrically developed. The *first maxilliped* is nearly as broad as long, and bears 15 long hairs on its margin. The basal segment of the *second maxilliped* presents four rounded processes on its inner margin, of which the first is smallest and bears one bristle, the second and third are sub-equal and bear respectively two and three bristles, and the fourth is largest, is much produced inferiorly (the rounded lower end being finely ciliate) and bears four bristles.

The *fifth pair of legs* in the female is bi-ramose, the inner branch straight, slender, not jointed, terminating in two short claws; the outer strong, two-jointed, terminating in a single slightly serrate claw. The second joint of this branch bears two slender bristles near the middle of the outer margin, otherwise the leg is destitute of hairs and spines. The *legs of the fifth pair* in the male are very dissimilar. The right leg consists of five joints; the basal quadrate; the second about twice as wide as long, enlarging distally and bearing a strong blunt spine at the inner, and a longer one at the outer, inferior angle. The third joint is sub-quadrate, the fourth clavate, bearing a long bristle at the middle of its outer margin; and the fifth constitutes a slender incurved dactyl as long as the preceding joint, slightly serrate on the distal half of its inner margin, and so jointed as to close back against the inner margin of the fourth joint, which thus acts as a hand. The left leg reaches about to the tip of the third joint of the right. Its pedicel contains two large quadrate joints; the outer ramus two small joints, of which the terminal one is forcipate at the tip, the inner ramus a single slender joint on which no armature was seen. The *furca* bears at tip of each branch four long feathered hairs, and a fifth smaller simple one at the posterior internal angle. A sixth large and plumose hair is borne at the posterior third of the outer margin.

Found rather abundantly in a pool fed by a slow spring, in March and April, at Normal, Illinois. In several characters, especially those of the mouth appendages, this species seems closely allied to Ichthyophorba, bearing to some species of that genus a much closer resemblance than to *D. castor*, if the figures in Baird's British Entomostraca are at all to be relied on.

KEY TO THE SPECIES MENTIONED IN THE PRECEDING PAPER.

The general neglect of our crustacea by the students of our local natural history, if not a discredit, is at least a misfortune; for no other class of animals accessible to the inland student will repay study so promptly and so generously; since while the species are comparatively very few, they present many and extreme diversities of form and structure. The differences between the *orders* of this class,—between the *families*, even, of some of the orders,—are more profound, penetrate farther into the interior of the animal, affecting structures commonly far more stable, than do the differences between the other *classes* of the sub-kingdom. In the same order hearts may be present or absent, in the same tribe gills may be filamentous or lamellate, in the same genus so complex an organ as the eye may be well-developed or entirely wanting; and everywhere not external form alone seems plastic, but internal structure also. Indeed, this is but an instance of a more general truth. In every well founded sub-kingdom the lowest class stands nearest the point of common origin,—illustrates, therefore, most closely by its diversities the first divergencies of the group from which the later groups have sprung In this primeval group structure must have been much more unstable than in the later higher ones, else the stable structural characters which now distinguish classes could never have arisen; and in the lowest present class, which has departed least from the condition of this primeval group, this instability of structure may be expected to persist,—structural differences will have less "value" for purposes of classification.* Hence in the study of the few examples of this lowest class of arthropods, we rapidly acquire a more fruitful knowledge of nature's multiform adjustments, encounter more numerous and suggestive illustrations of her general laws, than by much longer and more elaborate study of the higher groups. For the amateur and the beginner the crustacea have further a peculiar interest from the fact that the transparency of some of the smaller forms makes possible the direct and easy study of the entire living organism. Nothing better could be devised for the luminous demonstration of the leading facts of animal physiology. In a single colorless *Asellus* or *Crangonyx* may be observed at leisure, under a low power of the microscope, the respiratory movement, the circulation of the blood, the motions of the heart and the actions of its valves, the contraction and relaxation of muscular fiber, the processes of digestion, as well as the general and minute anatomy of the entire animal.

The economical interest of the subject should not be overlooked. With the progressive settlement of the country we must look forward to a continuous advance in the price of animal food, and with this advance the question of our inland fisheries will rise yearly into higher prominence. But intelligent measures for the increase and preservation of our edible fishes

*This principle, that *structural characters diminish in importance downward*, has been ignored, I think, by some of our recent ichthyologists.

presuppose an acquaintance with the natural history of our crustacea, which are as essential to fishes as insects are to birds.

With a view to removing some of the many difficulties which have prevented a more general study of this captivating and important class, I add to the foregoing paper the following simple synopsis of the species mentioned, which it is hoped that any intelligent student may use successfully. It is of course a mere compilation designed as a temporary aidto local students. A few species from Lake Michigan have been included which have not yet been found within the limits of the state, but which must nevertheless occur there at least occasionally.

CLASS CRUSTACEA.

Arthropoda usually with jointed abdominal appendages and two pairs of antennae. All save a few minute forms with more than four pairs of legs. Respiration by distinct gills, by gill-feet, or by the general surface of the body.

ORDER DECAPODA.

Head and thorax consolidated, forming a cephalo-thorax ; eyes compound, on flexible stalks.

FAMILY ASTACIDAE.

Abdomen depressed, carapace (1) with a transverse channel, edge united with the epistoma (2) ; gills very numerous, composed of filaments ; the three front pairs of feet chelate (3), the first much the largest.

Genus Cambarus.

The fifth pair of legs without gills ; last segment of thorax movable. Rostrum (4) simple or with one tooth on each side. First abdominal legs of male (5) more less divided.

a

Oblique tubercle on front margin of third joint of third and fourth pairs of legs of male.

C. acutus, *Girard*. Areola (6) much wider behind than before. Thorax densely tuberculate on sides, nearly smooth above. Movable finger much longer than inner side of hand.

C. troglodytes, *Lecomte*. Areola narrower behind than before. Thorax granulate on sides, strongly punctate above. Movable claw not longer than hand.

aa

Oblique tubercle on third joint of third pair of legs of male, none on fourth pair.

b

First abdominal legs of male not distinctly bifid.

C. gracilis, *Bundy*. Rostrum broad, short, toothless ; finger not hairy ; first abdominal leg toothed but not recurved at tip.

C. stygius, Bundy. Rostrum long, triangular, with small apical teeth; outer margin of finger hairy; first abdominal legs recurved at tip and three-toothed.

bb

First abdominal legs of male distinctly bifid.

c

C. obesus, Hagen. First abdominal legs short, thick, branches stout, tips recurved, obtuse. Areola linear.

cc

First abdominal legs of male with branches usually long and slender.

d

C. immunis, Hagen. Both branches gradually, strongly and equally recurved. Rostrum short and conical.

dd

Branches not strongly and equally recurved.

e

C. propinquus, Girard. Rostrum carinated (7) on middle of anterior half.

ee

Rostrum not carinated.

C. placidus, Hagen. Rostrum excavated, margins thickened; maxillipeds not hairy beneath; greatest width of hand contained about three times in length of outer margin, inner edge of outer finger not bearded, forearm without two rows of distinct spines beneath.

C. virilis, Hagen. Rostrum sub-excavated, margins thickened, hardly converging; antennal plates not longer than rostrum; maxillipeds bearded without, beneath and within; greatest width of hand about two and one-third times in length of outer margin, outer finger bearded within, forearm with two rows of distinct spines beneath.

C. wisconsinensis, Bundy. Rostrum nearly flat above, narrowed in front; antennal plates longer than rostrum; maxillipeds hairy within and below at base.

FAMILY PALAEMONIDAE.

Abdomen compressed. Carapace without transverse channel, its lower edges free throughout. Gills composed of plates. The third pair of feet never chelate.

Genus Palaemon.

Rostrum long, compressed, serrate; two inner antennae with flagella (8), mandibles (9) with three-jointed palpus (10), first pair of legs slender, second stronger, both chelate.

P. ohonis, Smith Rostrum slightly curved upward at tip, about twelve teeth above and three to five below. Hand of second pair of legs about once and a half the length of the carpus (11).

Genus Palaemonetes.

Differs from *Palaemon* by the absence of mandibular palpi.

P. exilipes, *Stimpson*. Rostrum nearly straight, seven or eight teeth above, one or two below. Hand of second pair of feet about two-thirds as long as carpus.

FAMILY MYSIDAE.

Feet more than five pairs, slender, often bearing palpi, none chelate, usually rudimentary on the abdomen. Gills wanting.

Genus Mysis.

Six pairs of thoracic feet, each with two many-jointed branches; three pairs of maxillipeds (12). Inner antennae with two flagella. Fourth pair of abdominal legs in male very long, styliform, directed backwards.

M. relicta, *Loven*. Cephalo-thorax about one-third total length, broader behind than before. Pedicel (13) of inner antennae a little longer than the eyes, three-jointed, first joint about as long as second and third together. Inner flagellum shorter and more slender than outer.

ORDER AMPHIPODA.

Body commonly compressed, of fourteen segments; thoracic segments not consolidated, eyes sessile if present. Gill plates thoracic.

FAMILY ORCHESTIDAE.

Upper antennae shorter than lower, no secondary flagellum (14). No palpus to mandible. Epimera (15) large. Last pair of abdominal legs not branched.

Genus Hyalella.

First two pairs of feet sub-chelate (16), the second the larger; upper antennae as long as peduncle of lower; telson (17), short, stout, entire; palpus of maxillipeds five-jointed; first pair of maxillae with very short one-jointed palpi.

H. dentata, *Smith*. First and second abdominal segments with a prominent tooth on middle of hind margin, second hand of male about three times as broad as first, flagellum of lower antenna commonly but little longer than that of upper.

FAMILY LYSIANASSIDAE.

Body little compressed, first two pairs of feet small and weak, epimera of first four segments very deep.

Genus Pontoporeia.

Upper antennae with short secondary flagellum; first two pairs of legs very short, the first sub-chelate, the second not, seventh pair with basal joint very large.

P. hoyi, *Smith*. First pair of hands with one to three small slender spines at tip of closed claw. About seven elongated papillae on the second to fifth segments of the sternum (18). Upper antennae short, about as long as head and first three thoracic segments; flagellum about nine-jointed.

P. filicornis, *Smith*. Upper antennae reaching nearly to tip of abdomen, flagellum of about thirty-three joints, the terminal ones very long and slender. Secondary flagellum of four segments.

FAMILY GAMMARIDAE.

Both antennae well developed, the upper long, slender, filiform, usually immediately above the lower, which are inserted into a notch at the front angle of the head. First and second feet sub-chelate. Eyes compound, commonly between upper and lower antennae.

Genus Gammarus.

No rostrum. Three last abdominal segments each with two or more clusters of short stiff spines on hind margin. Secondary flagellum and mandibular palpus present. Last pair of abdominal legs two branched; telson double.

G. fasciatus, *Say*. Secondary flagellum as long as second segment of peduncle (19), and composed of five or six segments. Fourth, fifth and sixth abdominal segments each with three clusters of spines on hind margin.

Genus Crangonyx.

No clusters of spines on posterior abdominal segments. Telson single; last pair of abdominal legs with inner branch rudimentary or wanting. Peduncles of the two pairs of antennae sub-equal. The first two pairs of feet sub-equal.

C. gracilis, *Smith*. Eyes evident. Hind angles of first three abdominal segments each ending in a sharp tooth. Outer branch of last pair of legs about twice as long as peduncle: inner branch very small. Telson short, emarginate.

C. mucronatus, *Forbes*. No eyes. Hind angles of first three abdominal segments rounded. Outer branch of last pair of legs shorter than peduncle, inner minute. Telson of male a slender spine about as long as first three abdominal segments.

ORDER ISOPODA.

Body commonly depressed; thoracic segments not consolidated; eyes, if present, compound, sessile. Gill plates beneath abdomen. The last four pairs of thoracic legs similar, and differing from the first three pairs. Last pair of abdominal legs more or less styliform.

FAMILY ONISCIDAE.

Abdomen many-jointed, last segment small, caudal stylets (20) well exserted. Mandibles without palpi. Inner antennae obsolete.

FAMILY ASELLIDAE.

Body very flat, loosely jointed. Last abdominal segment very large, shield-like, comprising nearly the whole abdomen. Upper antennae short, lower very long. Only first pair of feet sub-chelate. Mandibles with palpi.

Genus Asellus.

First pair of feet sub-chelate; last thoracic legs not elongate; first pair of abdominal appendages in female (first two pairs in male) small, forming short plates; outer ramus of next pair serving as gill-covers; caudal stylets elongate.

A. brevicauda, *Forbes*. Head with hind angles laterally extended, forming broad spinous lobes; front angles of first thoracic segment notched, no lateral notches on thoracic segments; tip of abdomen with broad rounded lobe, pedicels of caudal stylets as broad as long, palm of hand with two strong spines.

A. intermedius, *Forbes*. Head with small lateral lobes. First thoracic segment with front angles entire, others notched laterally; hind angles of abdomen not distinct, pedicel of caudal stylet twice as long as wide.

A. stygius, *Packard*. Slender, loosely-jointed, colorless and blind; caudal stylets slender, cylindrical, abdomen not lobed behind.

ORDER PHYLLOPODA.

Feet, ten to sixty pairs, broad and flat, two or three-lobed; mouth with mandibles and maxillae, antennae usually small, not used for swimming.

FAMILY BRANCHIPODIDAE.

Body long and slender, no carapace, thoracic segments distinct, eyes on stalks, second antennae converted into clasping organs. Eleven pairs of gill-feet. Female with egg-pouch at base of abdomen.

Genus Eubranchipus.

Head large, claspers (21) of male thick and strong, with a tooth at base of second joint; a pair of simple, flat, serrate, membranous appendages attached to front of head; caudal appendages long, lanceolate, with many feathery hairs. Egg-pouch short, thick, broad-oval.

E. serratus, *Forbes*. Frontal appendages longer than claspers, irregularly ovate, deeply serrate. Tip of claspers flattened within, abdomen somewhat serrate.

FAMILY ESTHERIADAE.

Compressed; head and body enclosed in a bivalve shell. Eyes sessile; feet, ten to twenty-seven pairs.

Genus Limnetis.

Shell circular, globose, no beaks or lines of growth. Inner antennae two-jointed; feet ten or twelve; abdomen truncate.

ORDER CLADOCERA.

Body enclosed in a bivalve shell, head free; abdomen acutely forked; eye single, large. Lower antennae form large branched swimming organs; feet four to six pairs.

FAMILY DAPHNIADAE.

Upper antennae minute, one or two-jointed; five pairs of feet, all enclosed by carapace. Intestine nearly straight.

ORDER OSTRACODA.

Biting mouth, one eye, two pairs of antennae, one for swimming; bivalve carapace enclosing head and body. Feet one to three pairs.

FAMILY CYPRIDAE.

Upper antennae long, many-jointed, with a tuft of long hairs; lower stout and foot-like; two pairs of feet.

ORDER COPEPODA.

Body more or less distinctly segmented, and distinguishable into regions; two pairs of antennae, one or two antennae often prehensile. No carapace or bivalve shell; three pairs of mouth-parts and five pairs of swimming feet. Females with external egg-sac.

FAMILY CYCLOPIDAE.

Both anterior antennae modified for grasping in male. Posterior antennae four-jointed, not branched. Fifth pair of legs cylindrical, alike in both sexes. One eye, with two lateral lenses; two egg-sacs.

Genus Cyclops.

Body broad in front, slender behind, of ten segments in males, nine in females. Head and first thoracic segment consolidated. Palpus of mandible rudimentary, a tubercle bearing two bristles. Fifth pair of feet obsolete.

FAMILY HARPACTIDAE.

Body linear, cylindrical. Both anterior antennae of male modified for grasping. Posterior antennae branched, and armed with jointed bristles. The fifth pair of feet usually lamellate. Eye single. Commonly a single egg-sac.

Genus Canthocamptus.

Branches of the first pair of feet similar, three-jointed, the inner branch the longer, its first joint very long. Palpus of mandible simple, two-jointed. First antennae eight-jointed. Secondary branch of second antennae very short, one or two-jointed.

C. illinoisensis, *Forbes*. Minute, light red; five abdominal segments in male, four in female. Branches of furca (22) as wide as long. Of the bristles at their tip, the inner is about as long as the abdomen, the outer half the inner. Mandible with about ten teeth.

FAMILY CALANIDAE.

Body elongate; anterior antennae very long, usually of twenty four or twenty-five joints. In males the right—rarely the left—is modified for grasping. Posterior antennae large, two-branched. One egg-sac.

Genus Diaptomus.

Fifth pair of feet unlike in males, inner branch of right foot rudimentary or wanting. This foot is converted into a grasping organ, as is also the right antennae of the male. Antennae twenty-five jointed. Fifth thoracic segment distinct. Abdomen of male with five joints, of female with four.

D. sanguineus, *Forbes*. Color crimson. Right foot of male without inner ramus, the last two joints forming a hand and dactyl. Each branch of the furca bears six plumose hairs, of which the inner is slender and short. The teeth of the mandible are entire.

1. The crust covering cephalo-thorax on back and sides. 2. Under surface of head betwee i the lower antennae. 3. Furnished with nippers. 4. Projection from front of head, between antennae. 5. In the male crawfish the first abdominal legs are stiff and unlike theothers; in the female similar to the others, but rudimentary. 6. Space on back of thorax between the two longitudinal curved lines. 7. Ridged longitudinally. 8. The many-jointed terminal part of antennae 9 Front pair of jaws. 10. Jointed feelers. 11. Joint preceding hand. 12. Hind pairs of jaws. 13. The thick, longer-jointed basal part of antennae. 14. A very short flagellum attached beside the principal one. 15. Side-plates concealing attachment of legs. 16. Last joint claw-like, shutting against the enlarged preceding joint like the blade of a pocket-knife against its handle. 17. Rudimentary last segment of the body. 18. Under surface of the body between bases of the thoracic legs. 19. Undivided basal joint of leg. 20. Pair of appendages at tip of abdomen. 21. The strong, jaw-like organs in front of head. 22. The forked tip of the abdomen.

APPENDIX.

Descriptions of the following extra-limital species are added for the purpose of calling the attention of collectors to them, as it is very likely that they will be found in the state. The descriptions of crawfishes are furnished by Mr. Bundy, who has made a careful study of the species of Cambarus found in this and adjoining states.

C. sloanii, *Bundy*. Rostrum quadrangular, subdeflexed, slightly concave, toothed in front, acumen long, acute, straight, cephalo-thorax, finely punctate above, granulate on sides, front margin angulated, lateral tooth long, acute; epistoma wider than long, narrower in front, concave below, apex emarginate; third maxillipedes smooth below, hairy within, hands short, thick, wide, smooth, fingers short, straight, not gaping at base, generally tipped with black, arm and wrist nearly smooth, at most with a few blunt teeth; third legs with third joints hooked; first abdominal legs short, bifid, outer part slightly longer, flattened, bent outward at apex, slightly recurved, acute, tubercles at inner base small, inter-pedal space once and one-half longer than wide. The female has ventral ring rhomboid, posterior angle swollen, irregularly tuberculate, fissure transverse, anterior angle depressed. Habitat: Southern Indiana, Kentucky (*Dr. Sloan*).

C. debilis, *Bundy*. Rostrum wide, quadrangular, subdepressed, concave above, foveola at base, margins nearly parallel, anterior teeth prominent, acumen acute, flat, smooth, cephalo-thorax subdepressed, punctate above, granulate on sides, lateral tooth acute, dorsal area narrow, wider behind,

antennal plates longer than rostrum, apical spine acute; antennae slender, long, reaching to base of telson, epistoma much wider than long, truncate, maxillipedes barbate on inner side and below; inner margin of hand and movable finger with two rows of teeth, contiguous margins of fingers tuberculate, exterior one hairy at base, both fingers ribbed and punctate above, third joint of third thoracic legs hooked; first abdominal legs long, bifid, nearly straight, exterior part longer, recurved, interior part recurved, obtuse, not enlarged near apex, tubercles on inner basal angles small. This species resembles the above, but differs from it in having a wider, more concave rostrum, with parallel sides, a depressed dorsum, wider epistoma, more coarsely bearded maxillipedes, longer abdominal legs, and the absence of enlargement near apex of interior part. Habitat: Baraboo river, Ironton; Wisconsin river, Sauk City, Wisconsin.

Eubranchipus bundyi, *Forbes*. This species, sent me by my friend Prof. Bundy, was taken by him at Jefferson, Wis. The specimens seen were somewhat smaller than average individuals of *E. serratus*, the thorax shorter and the abdomen more slender. The latter is similar to the abdomen of *E. vernalis*, while the claspers and frontal appendages are more like those of *E. serratus*.

The *antennae* extend about one-third their length beyond the eyes. The *frontal appendages* are long and narrow, widest at base and regularly tapering, serrate within and on outer margin of tip with short blunt even teeth. The under surface is covered with short blunt spines or tubercles.

These appendages are attached by a transverse line to the front of the head, just within the base of the claspers, and are about three times as long as the basal joint of the latter.

The *claspers* resemble in size, general form and position those of *E. serratus*. The tubercle at the base of the first joint is larger and situated farther forward, extending far enough to the front to meet its fellow of the opposite side before the labrum. The opposed edges are somewhat roughened. The *labrum* is large and extends forward in the form of a stout tubercle, truncate at its extremity. This process is embraced by the concave posterior internal margins of the basal tubercles of the claspers The second joint of the clasper is thick at base, but tapers more rapidly than in *E. serratus*. The long and slender tooth of the latter is replaced by a thick rounded tubercle extending directly inward and covered by elevated disks, or truncate papillae, like the tip of the tooth in the species just mentioned. Unlike the latter, these papillae are wanting at the tip of the joint, which is expanded and distinctly bifid.

The margins of the *abdomen* are not distinctly serrate, the last segment is not connate with the penultimate, nor is the tip of the abdomen broader than the preceding segments.

The *caudal stylets* are broad and blunt, not rounded at base, usually a little longer than the last three abdominal segments, and ciliate their whole length. The ovisac of the female is nearly as broad as long, with a large median lobe behind, and no other posterior processes.

THE TREE IN WINTER.

By Frederick Brendel

When autumn has turned the verdancy of the forest into discolored hues, and the roaring gales have shaken off the last withered leaf,

> "And woods, fields, gardens, orchards, all around
> The desolated prospect thrills the soul,"

even then nature is not dead, she sleeps only. The new life lies hidden in the bud, born early in summer from the axil of the leaf.

It is our own fault, if in the bare forest we see only a crowd of wooden trunks and limbs and twigs. There is in winter an abundance of objects to be studied by the naturalist. The book of nature lies open at every season to the attentive eye.

To recognize the different trees in winter is not only amusing to the friend of nature, but in many cases of great practical use. To expose the characters by which the species of our woody plants can be distinguished in winter, is the aim of this paper. As the space allowed is not sufficient for a synoptical description of each single species,—matter enough to fill a book,—the reader cannot expect more, in these few lines, than an introduction to the subject, and may accept this as an invitation to inform himself by autopsy and study, assisted by the most necessary drawings.

Everybody will easily recognize, even at a distance, an old oak tree by its stout stem, its strong crooked divaricate limbs; or an elm by its domelike appearance, caused by its numerous twigs dividing from a number of primary limbs of equal strength; or a *Gymnocladus* by its slender stem with but few branches and comparatively thick twigs. In some trees the bark is characteristic: that of the hackberry is very rough with narrow elevated ridges, while that of the beach and hornbeam is quite even and smooth. The bark of the shell-bark hickory separates the outer layers in long flaps, while in the mockernut and bitternut it is compact, and often nearly smooth; sometimes the bark of the stem is rough and that of the limbs smooth, as in the red oak; the bark of the twigs is often corky-ridged (*Quercus macrocarpa*), or separates in small flaps (*Quercus bicolor*), or bears two opposite corky ridges (*Ulmus alata*). In many trees the ridges anastomose obliquely, leaving lozenge-shaped spaces. The white color of the bark of the canoe birch is very characteristic. The whole division of white oaks differs from that of the black oaks by the color of the bark, which is paler in the former and darker in the latter. We have no surer guide than the characters taken from the arrangement, form and construction of the buds and, in many cases, the form of the leaf-scars.

PHYLLOTAXIS.

As the buds grow from the axils of the leaves, their arrangement is the same as that of the leaves. They are either opposite or alternate.

When the buds are opposite, one pair stands transversely to the next lower, so that, when seen from above, the four buds form a cross, as do also the leaves and the branchlets; the third pair corresponds to the first one. This position is called decussate, and we find it in the species of Euonymus, Staphylea, Aesculus, Acer, Negundo; Hydrangea, Cornus (except C. *alternifolius*), Lonicera, Sambucus, Viburnum, Bignonia, Tecoma, Fraxinus, Foresteria.

A whorl of three buds we find in Catalpa, and also usually in Cephalanthus (sometimes four or only two). Each whorl alternates with the next one, so that, seen from above, a whorl of six is formed. In all the rest of our woody plants the buds are alternate. Though seemingly irregular they are arranged in a definite order. The buds are alternate in two lines (bifarious), or in other words the third bud corresponds to the first, the second to the fourth; two buds make one circuit, and this is expressed by the fraction $\frac{1}{2}$; the numerator indicates the circuit, the denominator the number of buds. This arrangement we find in the species of Asimina, Vitis, Ampelopsis, Cercis, Hamamelis, Brunnichia, Dirca, Ulmus, Celtis, Morus and Smilax.

In Betula and Alnus three buds make one circuit in a spiral line; the fourth bud stands above the first ($\frac{1}{3}$).

In the majority of our woody plants five buds make two turns in a spiral line, and the sixth bud stands above the first (two-fifths). In the oaks the upper buds are somewhat crowded. The beech and Tilia, though properly belonging here, have the buds on the horizontal branches in two opposite lines.

There is one little tree (*Ptelea*) with eight buds in three circuits ($\frac{3}{8}$), and one shrub (*Amorpha fruticosa*), with thirteen buds in five circuits (five-thirteenths). In Rhamnus four buds make one circuit, but the merithalls* between the first and second and the third and fourth, are much shorter than between the second and third; and as we sometimes find the pairs of buds in Euonymus and Fraxinus displaced (one higher than the other), we may conclude that Rhamnus belongs to the same division as those. The position is properly decussate. The same conclusion we may make in regard to the elm, the seedling of which has opposite leaves; and perhaps we may explain the bifarious position of the buds on the branches by a (hypothetic) torsion of the merithalls.

The best way to count the buds and their circuits, is to thrust a pin into each leaf-scar at a right angle to the stem, and attaching a thread to it, pass this from the lower to the next higher until the one is reached which corresponds to the first one.

Figures 18—21 on Pl. IV show in diagram the phyllotaxis of four different woody plants. The figures represent the bark split longitudinally

*Internodes.

and laid flat. The lines represent the vascular bundles, which enter the bud at the numbered points. In Fig. 19 we see that the fibres of two-fifths of the vascular ring enter into one leaf. If we segregate the merithalls and put the buds at the same level, we have a whorl of 5, 8 and 13, and the whole number of buds represents a whorl pulled out into a spire.

There are sometimes supernumerary buds in some species of Juglans, Carya, Gymnocladus, Amorpha, Gleditschia; two to even four buds appearing one above the other. The uppermost develops, or it forms an abortive twig, a spine (Gleditschia); then the next lower develops, the lowest remaining dormant. In Crataegus the axillary bud is often transformed into a spine, when an accessory bud appears on both sides.

The species with opposite buds have a true terminal bud. This is sometimes abortive and wanting in *Euonymus* and *Staphylea*, or the shoot had an indefinite growth and withered in fall at the upper end, as in *Sambucus*, *Tecoma*, *Catalpa*, *Cephalanthus*. Then of course there is no terminal bud.

SIZE AND FORM OF THE BUD.

The buds of our woody plants are formed in summer, and are visible during winter. Only *Gleditschia* and *Robinia* show no buds in winter; these are hidden in the bark and break forth only in spring. Others show only a little knob (*Ptelea*, *Cephalanthus*). There are a number of trees which have very large buds, at least at the upper end of the shoot (*Aesculus*, *Fraxinus*, *Juglans*, *Carya*, *Populus*), others very small ones (*Cercis*, *Celastrus*). The buds are either leaf-buds or flower-buds or mixed, containing leaves and flowers at once. The latter are quite similar to the leaf-buds; the flower-buds are mostly more roundish and swollen, and placed at the lower part of the shoot (*Fraxinus*), but some flower-buds are cylindrical and appear (in *Rhus aromatica*) at the upper end of the shoot.

The true terminal bud of the species with decussate buds and the pseudo-terminal bud of the species with alternate buds, are often much larger than the axillary buds; and, as these are often the only ones that produce new shoots, these trees show in winter a limited number of long branches. When we examine such branches, we find sometimes a row of shoots, each with a few approximated leaf-scars, and below these a ring of narrow scars of the bud scales, fixing the limit of each shoot, and then a long shoot with remote buds. (*Fagus*, Fig. 16 on Pl. II, and *Cornus alternifolius* Fig. 9 on Pl. III.) By counting these shoots we can determine the age of the branch

The bud is fusiform, often very slender (*Amelanchier*, *Cornus*, *Virburnum lentago*); or ovate, more or less pointed (*Aesculus*), or oval and obtuse (*Diospyros*, *Ulmus fulva*), or globular (*Crataegus*), or compressed (*Asimina*, *Liriodendron*, *Hamamelis*).

DIRECTION OF THE BUDS.

The axis of the bud stands mostly at an angle of 15 to 45 degrees to

the axis of the branch, sometimes at a right angle (*Fagus*, *Celastrus*); or the bud is appressed, the axis being parallel to the shoot (*Cornus*, *Virburnum*, *Salix**).

The axis of a bud which stands straight above the leaf-scar is radial, it points to the centre of the branch; but in some species, particularly in those with bifarious buds (*Morus*, *Celtis*, *Ulmus*, *Tilia*) the bud stands not right above the leaf-scar but a little aside, then the direction of the bud is oblique, and its axis is tangential, it strikes the periphery of the shoot. The axis itself is sometimes not straight, but bent (*Celtis*, *Ulmus*).

THE SCALES OF THE BUD.

The number of scales is not always definite. It is said to be ten in *Carya alba;* and yet I have counted in the upper bud a greater number, sometimes even as many as twenty, though in many species the number is constant. *Salix* has the bud covered by a single hood-like scale, *Tilia* has two, the inner one larger and enveloping the bud with overlapping margins. In *Negundo* and *Staphylea* one pair is visible, the inner ones are herbaceous and pass into leaves. *Acer dasycarpun* has four pairs, and *Acer saccharinum* eight pairs, *Aesculus* four opposite rows of five to six scales each. *Fraxinus* and *Euonymus* have three pairs.

The arrangement of the scales follows the rule of Phyllotaxis. In the bifarious species the scales are arranged in two rows, and there are four scales in each row (in *Ulmus*, *Celtis*, *Morus*). In those with five buds in two circuits the buds have the same arrangement, they are imbricate.†

The form of the scales is often variable in the same species and the same individual. It is mostly ovate and convex, pointed (*Aesculus*, *Populus*, *Quercus coccinea*), or mucronate (*Crataegus*), or obtuse (*Corylus*, *Quercus nigra*). The scales are pinnately grooved at the upper end in many species with pinnate leaves (*Fraxinus*, *Juglans*, *Carya amara*).

The surface is smooth (*Crataegus*, *Quercus rubra*), or pubescent (*Fagus*, *Carya alba*), or tomentose (*Rhus glabra*, *Ulmus fulva*, *Quercus coccinea*), or sericeous (*Dirca*), or velvety (*Asimina*), or furfuraceous (*Carya amara*). The color is mostly brown, but sometimes green (*Euonymus*), yellow (*Carya amara*, *Dirca*, *Liriodendron*), rusty red (*Zanthoxylon*), bluish black (*Fraxinus sambucifolia*), purplish brown (*Asimina*). Some have a darker colored zone along the margin (*Morus*).

VERNATION.

When we cut a bud horizontally, we observe the inner arrangement, the position of the leaves and their parts. In the species with decussate

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*In Salix cordata Var. angusta, only the flower-buds are somewhat spreading.

†M. C. De Candolle (*Memoire sur la famille des Juglandees*) calls the buds of *Carya olivaeformis* and *amara* decussate. That may be true concerning the lateral buds; in the terminal buds, as many as I have examined, I have found the phyllotaxis invariably 2-5.

The same author differs from other botanists in his phyllotaxis, since he passes from one scale, bud or leaf to the next on the longest and not on the shortest line, and thus, of course, makes three circuits instead of two.

buds the pairs stand at right angles, the lower ones outside, those higher on the shoot inside (Pl. I, Figs. 21–25). In the bifarious species the leaves are located side by side, the lowest outside, the highest in the middle, the posterior side of the midrib looking toward the leaf-scar (*Ulmus*, Pl. IV, Fig. 14); or they stand opposite, the lower inclosing the upper ones (*Celtis*, Plate IV, Fig. 15), the posterior side of the midrib looking toward the bud-scales. In those with the spiral position of the buds the leaves are arranged in the same way; the posterior side of the midrib looks toward the corresponding scale (*Populus*, Pl IV, Fig. 16). When the species has compound leaves, the leaflets lie either side by side or in a half-circle, the uppermost in the middle, the lower ones at the sides (*Carya alba*, Pl. IV, Fig. 17).

The blade of the leaf is either conduplicate (*Prunus**, *Amelanchier*, *Asimina*, *Cercis*, *Ulmus*, *Tilia*), or plicate (*Acer*, *Hamamelis*, *Ribes*), or involute (*Euonymus*, *Celastrus*, *Staphylea*, *Populus*, *Viburnum*), or revolute (*Salix*, *Ptelea*) or convolute (the leaflets of *Carya*, Pl. IV, Fig. 17), or equitant (*Cornus*, Pl. I, Fig. 24, or open and slightly concave (*Cephalanthus*, *Sassafras*).

A very singular arrangement we observe in *Liriodendron*, Pl. III, Fig. 4. The leaf is conduplicate and bent inward from the upper part of the petiole, and the cover of the bud is nothing else than the two stipules of an abortive leaf.

LEAF-SCARS.

At the base of the bud we observe the scar of the fallen leaf, an area of varying form, covered with a thin layer of corky matter which is formed in the latter part of the season and separates the leaf from the shoot; and within this area we notice the vestiges of the vascular bundles that enter the leaf-stalks.

The scars are either flat upon the stem (*Aesculus*), or on a projection, pulvinated (*Quercus*); they are sometimes concave (*Ampelopsis*, *Catalpa*), or convex (*Ulmus*).

The form of the scar depends on the form of the base of the leaf-stalk, and is very variable. It is narrow, nearly linear (*Negundo*), or crescent-shaped (*Cornus*, *Viburnum*), or triangular (*Populus*), or semi-circular (*Fraxinus*, *Quercus*), or elliptical (*Liriodendron*), or three-lobed (*Crataegus*, *Cercis*, *Amorpha*), with five sharp angles (*Lonicera flava*), or oval with the upper end truncate or emarginate (*Tecoma*, *Catalpa*, *Sassafras*), or heart-shaped (*Rhus toxicodendron*, *Gleditschia*, *Juglans*, *Carya*), or horse-shoe shaped (*Rhus glabra*, *Ptelea*), or ring-shaped around the bud (*Platanus*, *Dirca*). Here the bud was covered by the hood shaped basis of the leaf-stalk. In *Dirca* the bud is situated in a cup-like cavity the margin of which forms the leaf scar. When two scars of opposite leaves meet (*Negundo*), the twig seems to be articulated.

The marks of the vascular bundles are very characteristic, presenting sometimes one point in the center (*Celtis*), or a horizontal streak (*Sassafras*).

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*The European species of *Prunus* proper have convolute leaves.

Usually there are three points forming a triangle, or more and then forming either a curved line (*Asimina*), a horseshoe-shaped line (*Cephalanthus*), or a closed chain following the outline of the scar (*Morus*, *Sambucus*, *Fraxinus*), or separating in groups (*Juglans*, *Carya*, *Gymnocladus*). The marks are somewhat concave (*Aesculus*) or convex (*Lindera*).

THE TWIGS.

The direction of the twig commonly agrees with the direction of the bud. The *Sassafras* has a peculiar growth; the secondary shoots of the summer from the lower buds attain a greater length than the primary ones, and as the shoots are curved upward, the whole has the appearance of a chandelier (Pl. III, Fig 7). The shoots are either smooth (*Fraxinus americana and sambucifolia*, *Acer*, *Crataegus*), or pubescent (*Fagus*, *Betula*), or rough hairy (*Corylus*, *Ulmus fulva*), or tomentose-pubescent (*Fraxinus pubescens*, *Carya olivaeformis*, *Diospyros*), or prickly, and then the prickles are placed irregularly on the bark (*Rosa*, *Rubus*, *Smilax*), or there is only one on each side of the scar, representing a stipule (*Robinia*, *Zanthoxylon*). Prickles should not be confounded with spines (or thorns). *Ribes* has a spine below the persistent base of the leaf-stalk, and this represents a bract.

In many species we see ridges running downward from the leaf-scars (*Populus monilifera*, *Rhus toxicodendron*), in some species with opposite leaves these ridges are very sharp and prominent, and the twig becomes quadrangular (*Fraxinus quadrangulata*, *Euonymus atropurpureus*).

The color of the twig is mostly brown, but other colors occur, red (*Cornus sericea*), purplish (*Cornus alternifolia*, *Asimina*) yellowish (*Platanus*), green (*Sassafras*, *Euonymus*, *Staphylea*, *Negundo*), grayish (*Fraxinus sambucifolia*, *Rhamnus*), white, thickly covered with a white woolly pubescence (*Salix candida*).

THE PITH.

The pith in a horizontal section of a twig shows different forms in the different species, and in the same individual. In the middle of the merithall (space between two single leaves or pairs of leaves or whorls), it is more or less circular in the majority of our species; but sometimes it shows a hexagonal shape in species with opposite leaves; in those with five leaves in two circuits, a pentagon (*Sassafras*, *Liquidambar*), or a five-rayed star (*Quercus*, *Populus*). Near the upper end of the merithall (wrongly called "joint,") the form of the pith is modified by projections towards the leaf or pair of leaves.

The vertical section in *Juglans* and *Celtis* shows the pith in horizontal plates. I have observed this only in one other plant of our flora, the *Phytolacca*.

The color of the pith is mostly whitish, pure white in *Sassafras*, often with a rosy tinge in *Tilia* (cream color when older), yellowish in *Rhus glabra* and *Rhus toxicodendron*, reddish in *Gymnocladus*, *Cornus*, *Rhus aromatica*, greenish in *Gleditschia*, brownish in *Juglans cinerea*, *Carya amara*.

It is very large in proportion to the thickness of the wood in *Sambucus*, *Sassafras*, *Rhus*. Only *Smilax* has no pith: it belongs to the endogenous plants.

To treat of the wood here, would lead us too far, for the matter is too ample to be condensed into a small space.

The plates will aid somewhat in the identification of specimens.

SODIC PINATE AS A TEST FOR LIME.

By J. A. SEWALL.

Pinic acid or sodic pinate precipitate salts of calcium, magnesium and iron.

I have recently made some experiments with the sodic pinate, with reference to its delicacy as a test for detecting the presence of the salts of the first mentioned metal (calcium), with the following results, using a solution of calcic sulphate:

$\frac{1}{2500}$ part of calcic sulphate in one part of water, yields a very copious amorphous precipitate, which readily subsides.

$\frac{1}{5000}$ part yields an abundant bulky precipitate.

$\frac{1}{10000}$ part, an abundant precipitate.

$\frac{1}{25000}$ part, an immediate cloudiness, and in a few minutes a good precipitate.

$\frac{1}{50000}$ part, quite the same result as is given by the $\frac{1}{25000}$ solution.

$\frac{1}{125000}$ part, a very satisfactory deposit after a little time.

$\frac{1}{250000}$ part, a distinct turbidity, and after a few hours a satisfactory deposit.

I observe that on adding a few drops of the reagent to distilled water, the solution becomes, after several days, slightly opalescent.

The reagent was prepared by dissolving one part of the sodic pinate in fifteen parts of distilled water and filtering the solution.

The quantity of the solution of the calcic sulphate operated on in each trial was one fluid ounce. The quantity of the sodic pinate solution used in each trial varied from two to ten drops, the larger quantity being used in the stronger solution of the calcic salt.

Ammonic oxalate fails to precipitate lime in a $\frac{1}{65000}$ solution, (*Fresenius*).

It will be seen from the above that the sodic pinate is a much more delicate test for calcic salts than the ammonic oxalate. The deportment of other calcic salts is quite the same as that of the sulphate.

A PARTIAL CATALOGUE OF THE FISHES OF ILLINOIS.

By E. W. NELSON.

Owing to the slight attention the ichthyology of the region herein treated has received, the present catalogue must necessarily be very incomplete.

With the exception of Mr. R. Kennicott's list of fishes of Cook county, (Ill. Agl. Report) in which only thirty species are mentioned, and occasional descriptions of new species or the mention of the receipt of specimens from within our limits in the papers of various writers, nothing has been definitely known regarding the ichthyic fauna of the state. During the last three or four years, considerable collections of fishes have been made in various parts of the state, under the auspices of the Illinois Museum of Natural History.

The present paper is based mainly upon this material, which, through the generosity of the management of the above-named institution, I have been enabled to study. I am also greatly indebted to Prof. S. A. Forbes, Curator of the Museum, for notes upon the distribution and peculiarities of structure in many of the species. To Dr. D. S. Jordan, of Irvington, Indiana, I am under obligations for the loan of specimens, for invaluable aid in verifying doubtful identifications, and for notes on the distribution of many of the species, especially in the Wabash valley.

The collections in the Museum have been made principally by Prof. Forbes, in the following localities: Illinois river from La Salle to Pekin; the Vermilion river in La Salle county; Mackinaw creek in McLean county; Rock river at Oregon; Pecatonica river at Freeport; the Ohio and Mississippi rivers at Cairo; the outlet of Big Lake, in Jackson county; Callahan and Drury creeks, in Union county; Lake Michigan at Chicago, and some of the smaller tributaries of the above-named streams. In addition to these, small collections have been made by myself, from the Calumet river and its tributaries, in Cook county; Lake Michigan, at Chicago; small tributaries of the lake at Waukegan, and the Fox river at Geneva. Where species are included upon the authority of others, due credit is given. As will be seen by the list of localities, the streams from which collections have been made are nearly all tributaries, directly or through the Illinois, to the Mississippi, thus leaving the Wabash and Ohio with their tributaries comparatively unexplored, except portions of the Wabash valley, where collections have been made for Prof. Jordan; and so little work

has been done in the entire southern third of the state, that but slight idea can be formed of the exact distribution or of the number of species which exist there. The synonyms mentioned are only intended to connect the names here given with those used in Prof. Jordan's Manual of the Vertebrate Animals of the Northern United States.

FAMILY PERCIDAE.

Genus Microperca, Putnam.

1. *M. punctulata, Putnam.* Least Darter. Not uncommon in Fox river, at Geneva, and in clear tributaries to Lake Michigan at Waukegan. Not common in the Wabash valley.

2. *P. flabellatus,* (*Raf.*) *Cope.* Fan-tailed Darter. Common in clear brooks in Wabash valley.

3. *P. lineolatus,* (*Ag.*) *Jord.* Striped Darter. Found in clear streams in Northern Illinois, where it replaces the preceding.

4. *P. niger,* (*Raf.*) *Jord.* Trout Darter. Very rare in the Wabash valley.

*Genus Poecilichthys, Ag.**

5. *P. caeruleus,* (*Stor.*) *Ag.* Blue Darter. Common through Southern Illinois, and especially abundant in the Wabash valley.

6. *P. spectabilis, Ag.* Striped Blue Darter. Not so generally distributed as the preceding; is confined to the northern part of the state. In distribution this and the preceding species bear the same relations as *P. lineolatus* and *flabellatus.*

Genus Boleichthys, Grd.

7. *B. exilis, Grd.* Red-sided Darters. The only specimens I have seen from the state were taken in a clear brook flowing into Lake Michigan at Waukegan, where it was rather common.

8. *B. eos, Jordan, Mss.* Common in small clear streams in Northern Illinois and Southern Wisconsin.

For the following synopsis of the species of this genus I am indebted to Prof. Jordan: The characters ascribed to *B. fusiformis*, *B. erochrous* and *B. barratti* are from Cope (Proc. Phil. A. N. S., 1864, 233); those of *B. warreni* from Girard (Proc. Phil., A. N. S., 1859, 104).

*Lateral line distinct about to middle of first dorsal, on about 12 scales; 52 transverse rows; head $3\frac{1}{4}$ in length; D. VIII—9. Mass. *fusiformis* (*Grd.*)

** Lateral line distinct to middle of first dorsal, on 12 to 18 scales; head 4 in length. D. IX or X—10.

†Scales in 42 to 44 transverse rows; eye as long as snout, 5 in head; sides with dark band and reddish punctulations. New Jersey. *erochrous* (*Cope*)

††Scales in 45 to 50 transverse rows; eye 3 to $3\frac{1}{2}$ in head, longer than snout; sides with a row of round crimson spots (in life); form slender. Illinois to Montana. *exilis* (*Grd.*)

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* Includes *Catonotus, Notonotus* and *Poecilichthys. Jord. Man. Vert.*

***Lateral line on 20 to 30 scales.

‡ Head $3\frac{3}{4}$ in length; lateral line not to end of first dorsal; scales smallest, 60 in lat. l.; D. IX or X—9 or 10. Body fusiform, elongated, caudal peduncle notably much elongated; size large, life coloration brilliant. Northern Illinois and Wisconsin, *eos* (*Jordan*), *Mss.*

‡‡Head $3\frac{3}{5}$ in length; lateral line variously incomplete; scales rather large, in 45 to 50 transverse series, D. IX or X—12 to 14; caudal peduncle not elongate; body very short and chubby; size small; colors dull. Georgia to Texas. *elegans* (*Grd.*)

‡‡‡ Head 4 in length; lateral line extends to origin of second dorsal; 56 transverse series of scales; D. X or XI—10 or 11. South Carolina. *barratti* (*Holbr.*)

**** Lateral line unknown; body compact; head shorter than in *B. exilis*; scales smaller; first dorsal with a band of vertically elongated black spots; DIX—11, A II, 9. Cannon Ball R. *warreni* (*Grd.*).

Genus Pleurolepis, Ag.

9. *P. pellucidis*, *Ag.* Sand Darter. Found sparingly in clear sandy tributaries of the Wabash and Ohio. (*Jordan.*)

Genus Boleosoma, DeK.

10. *B. olmstedi*, (*Stor.*) *Ag.* Tessellated Darter. Specimens are in the collection from various localities, and Prof. Forbes informs me that he has found it common in all clear streams. Some specimens from Fox River in Wisconsin show characters exactly intermediate between this and the *atromaculata* of Girard. Other specimens from the Fox River at Geneva, Ill., agree with the description of *atromaculata*, and others from the same locality answer perfectly to *olmstedi*.

11. *B. brevipinne*, *Cope.* Slim Darter. Apparently everywhere common in clear streams throughout the state.

Genus Etheostoma, Raf.

12. *E. blennioides*, *Kirt.* Black-sided Darter. Rather common in the Wabash valley.

13. *E. phoxocephalum*, *sp. nov.* This species replaces the preceding in the western part of the state, and from the number of specimens in the collection and the localities represented, appears to be rather common in the Illinois and its tributaries.

Sp. Char. Head about 4 times in total length; depth $6\frac{1}{2}$; eye=snout, $4\frac{1}{2}$ in head; D. XIII—12. A. II, 8. Lat. l. 76. Inter-orbital space more than 6 in head. Cheeks naked; opercles scaly; breast naked. Middle line of belly with line of larger scales or a naked strip. Pectorals shorter than head. Fins mottled; sides with a lateral band of small squarish spots usually connected by a narrow black line. A black spot at base of caudal and one at base of lateral line.

Back mottled and tesselated with dark on a light ground. A black line from eye forward and another downward. This species bears a superficial likeness to *E. blennioides*, but may be distinguished at once by the

shape of the spots on the sides, by the much more slender form and very narrow, pointed, eel-like head, the depth of which is less than half its length, and its width two-fifths its length.

14. *E. evides. Jord., Mss.* Barred Darter. Rare. Occurs in the lower Wabash and Ohio valleys. (*Jordan.*)

Genus Percina, Hald.

15. *P. caprodes (Raf.), Grd.* Log Perch. A few specimens from the Calumet and Vermilion rivers. Becomes quite numerous in the Wabash valley.

Genus Perca, Linn.

16. *P. flavescens, (Mit.) Cuv.* Common Perch. Very abundant in Lake Michigan and its tributaries; also occurs, but in smaller numbers, in the Illinois and tributaries. Rare in the Ohio (*Jordan*). Specimens from the clear waters of Lake Michigan are usually a light color—almost white. Often the dark bars, generally so characteristic of the species, are so obsolete that the fish appears to be a clear, yellowish white, with the faintest trace of dark mottling, and the lake perch are rarely as decidedly barred as specimens taken in streams. The river perch may be at once distinguished by the heavy dark bars, and the dark greenish yellow color on the sides. So different are the two that I have several times heard persons speak of them as distinct species.

The aversion of the river form to the lake water and *vice versa*, I have often seen strikingly illustrated. The river bed of the Calumet is so slightly above the lake that during a hard north or northeast storm the lake water gradually forces back the water in the river,—often for a number of miles—and, as the cold lake water fills the channel, the river perch retreat, and their places are supplied by the lake form. As the storm subsides the current of the river forces the lake water back, driving before it the lake perch, and the river perch are again found in their usual haunts.

Genus Stizostedium, Raf.

17. *S. americanum, (Val.) Gill.* Pike Perch. Very common in Lake Michigan and the larger streams throughout the state.

18. *S. griseum, (DeK.) Milner.* Gray Pike Perch. Very abundant in the larger streams. Whether it occurs in Lake Michigan or not I am uncertain.

19. *S. salmoneum, (Raf.).* Salmon Perch. Ohio river and large tributaries. (*Jordan.*)

Genus Roccus, Mitch.

20. *R. chrysops, (Raf.) Gill.* White Bass. Exceedingly abundant in Lake Michigan. Common throughout the state.

Genus Morone, Mitch.

21. *M. interrupta, Gill.* Short-striped Bass. A number of specimens in the collection from Mackinaw creek and the Illinois river.

Genus Micropterus, Lac.

22. *M. nigricans, (Cuv.) Gill.* Large-mouthed Black Bass. Found in

great abundance throughout the state, as far as I can learn. The young are found in myriads in the ditches draining the marshes along the Calumet river.

23. *M. salmoides*, (*Lac.*) *Gill.* Small-mouthed Black Bass. Like the preceding, found in all parts of the state, and in nearly equal numbers.

Genus Centrarchus, Cuv.

24. *C. irideus*, (*Bosc.*) *C. & V.* Shining Bass. A single specimen, about three inches in length, is in the collection from a small stream flowing into the Mississippi, near Fountain Bluff, Southern Illinois.

Genus Pomoxys, Raf.

25. *P. hexacanthus*, (*C. & V.*) *Ag.* Calico Bass. Very abundant in the streams and small lakes in Northern Illinois, where it almost, if not entirely, replaces the following. Much less numerous farther south.

26. *P. annularis, Raf.* Croppie. Very abundant in all the streams through Central and Southern Illinois.

Genus Ambloplites, Raf.

27. *A. rupestris*, (*Raf.*) *Gill.* Rock Bass. Very abundant everywhere collections have been made.

Genus Chaenobryttus, Gill. (=*Glossopolites, Jord.*)

28. *C. gulosus*, (*C. & V.*) *Cope.* (=*G. melanops*, (*Gir.*) *Jord.*) Black Sun Fish. Prof. Forbes has found this species very common in the Illinois and tributaries through Central Illinois. Specimens have also been taken in Lake Michigan by Prof. Jordan.

Genus Telipomis, Raf. (=*Chaenobryttus, Grd.*)

29. *T. cyanellus, Raf.* Blue Sun Fish. Very abundant throughout the state in both large and small streams.

30. *T. microps*, (*Grd.*) *Nelson.* Common in the Calumet river in northeastern, and tributaries of the Illinois in central and western parts of the state.

31. *T. nephelus*, (*Cope*) *Nelson.* Occurs rather uncommonly in the Wabash valley; very hardy and voracious. (*Jordan.*)

Genus Ichthelis, Raf.

32. *I. incisor*, (*C. & V.*) *Holbr.* Blue Sun Fish. Abundant in all waters throughout the state.

33. *I. speciosus*, (*Grd.*) *Jord.* Rather common in the western part of the state in tributaries of the Illinois and Mississippi. Also a few specimens are in the collection of the author from the Calumet river. Although this species approaches closely to *incisor*, yet certain tangible distinctions, sufficient to distinguish the two at sight, are always present as far as my observations have extended.

34. *I. aquiliensis*, (*Grd.*) *Nelson.* A fine adult specimen is in the state collection from the Illinois, and a second less mature from the Fox river at Geneva is in my collection.

The following description is made from the adult specimen, seven inches long. Head, with flap, $2\frac{3}{5}$ in length; depth 2 1-6. Eye=snout, $4\frac{1}{2}$ in head. The eye is large but smaller than the opercular spot, and not quite equal to inter-orbital space. D. I, 12; A. III, 10; dorsal spines rather short and stout, as long as from snout to middle of orbit. Second anal spine stout, third as long as dorsal spines. Pectorals and ventrals long, about reaching anal, the ventrals being the longer. Ventral spine longer than dorsal spines. Body elongated, much elevated in front, heavy. General form and proportions of *I. obscurus, (Ag.) Jord.* Mouth wide for *Ichthelis;* maxillaries reaching to line from middle of orbit; fins high, spines rather low but very stout. Occipital region very prominent and narrow in adult. The caudal peduncle about as long as wide in front. Color in alcohol, dusky, mottled with orange and blue; cheeks with wide blue bands obscurely defined; dusky dorsal and anal spot. Belly and lower fins with orange and yellow shades, in life apparently coppery yellow; each scale on sides and back with a blackish, longitudinal oblong spot resembling the markings of *I. inscriptus.* Lower jaw and lower parts of cheeks a dull leaden blue, probably brilliant in life; blue line in front of and yellowish band around eye; opercular spot large, flap very broad and black, with a very broad pale edge entirely surrounding the black; the posterior width of edge more than half that of pupil; scales very large and crowded. Lat. l. 46; longitudinal rows 5-14; the lateral line very high; opercular scales large, those on cheeks moderate and six-rowed. Top of head flat and short, forming an angle with abruptly descending profile; rim of orbit slightly elevated. Coloration resembling that of *I. obscurus* and *Pomotis auritus.* Its nearest relative is the former, from which it differs in the presence of blue lines on the cheeks, wider snout and widely margined opercular flap. The smaller specimen bears considerable resemblance to *P. auritus*, being less gibbous and having the opercular flap smaller; it may be distinguished at once, however, by the large mouth and pointed pharyngeals.

35. *I. macrochira, Raf.* Gilded Sun Fish. A few specimens have been examined from tributaries of the Illinois and the Wabash valley.

36. *I. anagallinus, (Cope.) Bliss.* Red-spotted Sun Fish. One specimen in the collection from the Fox river.

I. inscriptus probably occurs in the southern part of the state, but I have seen no specimen.

37. *I. megalotis, Raf.* Long-eared Sun Fish. Rather common in the southern part of the state.

38. *I. sanguinolentis, (Ag.) Bliss.* Blue and Orange Sun Fish. Very abundant through the state, especially in northern part.

Genus Pomotis, Raf.

39. *P. auritus (L.) Gunth.* Common Sun Fish. Very abundant in the northern part of the state. Prof. Jordan informs me that it does not occur in the Wabash valley.

FAMILY APHREDODERIDAE.

In the present article I have the pleasure of adding a second genus to

this unique family: and, in consequence of certain characters present in the newly discovered form, the family characters of this group must now read as follows:

Fam. Char. Vent jugular or thoracic, either in front of or between the ventrals. Dorsal fin single, with three or four spines. Ventrals thoracic, without spines and with more than five soft rays. Some bones of head spinous; teeth on jaws and palate; scales ctenoid; branchiostegals six; coecal appendages about twelve; air bladder simple.

The following table shows the characters of the two genera of this family as they now stand:

Aphredoderus.	*Sternotremia, Gen. Nov.*
Vent jugular, in advance of ventral fins. Dorsal nearly equidistant between snout and caudal. Last anal spine short and rather slender.	Vent thoracic, between bases of ventral fins. Dorsal nearer snout than base of caudal. Last anal spine long and slender.

Below is a comparison of the specific characters of the two forms. I may here express my thanks to Mr. F. W. Putnam for the specimen of *A. sayanus* from which the following description is made:

A. sayanus, (*Gilliams*) *DeK.* Habitat, brooks near the coast from New York to Louisiana.

Vent nearer lower jaw than to ventrals, and less than twice the diameter of the eye from the junction of the gill membranes. Pectorals 1 3-5 in head. Ventrals the same. Longest dorsal ray the same. Longest dorsal spine 2½ in head. Longest anal ray, 1¾. Longest anal spine, 2¾. Caudal fin, 1 1-5. Diameter of caudal peduncle twice in head. Ventrals well separated, slightly decurrent. Vent opposite middle of opercle.

Longest anal spine less than from snout to middle of orbit. Scales considerably larger anteriorly, larger on opercle than on cheek. Lower posterior angle of cheeks about a right angle. Eye=snout, and also inter-orbital space. Ventrals considerably in front of dorsals. Distance from snout to anterior ray of dorsal 2½ times base of dorsal. Scales on cheeks and opercles large and loose.

S. isolepis, *sp. nov.* Habitat, small, weedy tributary to the Calumet river near Chicago, and small streams in South Illinois.

Vent more than twice as far from lower jaw as from ventrals; also more than three times the diameter of the eye from the junction of the gill membranes.

Pectorals, 1 3-5 in head. Ventrals 1¾. Longest dorsal ray, 1⅔. Longest dorsal spine, 2¼. Longest anal ray, 1¾. Longest anal spine 2, and as long as from snout to posterior border of orbit. Caudal fin 1¼ in head. Each scale with an edge of dark punctations, forming fine longitudinal streaks or lines. Vent behind end of opercle, and between bases of ventrals.

Diameter of caudal peduncle 1¾ in head.

Scales on body nearly equal, being, if anything, a trifle larger on the caudal peduncle. Scales on opercle slightly larger than on cheeks, the latter being scattered and imbedded. Angle of cheeks rounded and more than a right angle.

The distance from snout to anterior ray of dorsal less than twice the base of dorsal. Eye 1½ times in inter-orbital space, and more than once in snout.

Color of living specimen a clear greenish olive, lighter below; becoming yellowish or orange on abdomen.

Branchiostegals, 6.
Head in length, 2¾.
Depth, 3 1-10.
Eye in head, 4.
Dorsal IV, 10.
Anal, III, 6.
Ventrals, 7.
Pectorals, 10.
Lat. l., 44.
Longitudinal rows, 8–10.
The specimen of *Aphredodzreus* measures 3 inches.

Branchiostegals, 6.
Head in length, 3.
Depth, 3 1-10.
Eye in head, 4⅔.
Dorsal, III, 11.
Anal, III, 6.
Ventrals, 7.
Pectoral, 10.
Lat. l., 48.
Longitudinal rows, 10-11.
The largest specimen of *Sternotremia* from the dozen or more examined, is 2½ inches; the average is about 2 inches.

FAMILY SCIAENIDAE.

Genus Haploidonotus, Raf.

40. *H. gruuniens, Raf.* Sheepshead. Common in Lake Michigan and all the larger rivers.

FAMILY COTTIDAE.

Genus Cottopsis, Grd.

41. *C. ricei, sp. nov.*. Rice's Cottus. Through my friend Mr. F. L. Rice, of Evanston, I am enabled to make the present interesting addition to the lake fauna. The only specimen seen is the type, which was picked up on the shore of Lake Michigan near Evanston, and placed in my hands for identification by Mr. Rice.

Description: Head, 3 3-5; depth, 5 1-3; eye 4½, 1½ in inter-orbital space and equals snout; first dorsal 8, second dorsal and anal destroyed. Ventral I, 4; pectoral 15; palatine teeth present; body short and stout, head much depressed; back almost terete. Body abruptly contracted opposite base of anal; tail very small, sub-terete. Outline tadpole-like. Jaws about equal; mouth rather narrow; jaws contracted and somewhat produced; head very broad and flat, broader than body, breadth greater than length; depth half length. Eyes on upper surface, near together. Preopercular spine extremely large; three times as large as in any other fresh water cottoid known; as long as eye; hooked backward and upward, giving a buffalo-like appearance. Three spines hooked downward below the large spine; the lower concealed. A strong spine hooked forward at base of opercles. Branchiostegals 6. Isthmus as wide as from snout to middle of orbit. Base of pectorals crescentic, their tips just short of anal. Rays all simple. Ventrals under pectorals, decurrent.

Ventrals reaching ⅔ of the distance to vent. Profile rising rapidly to dorsal, which runs along a sort of carina. Dorsal beginning a trifle behind ventrals, just behind the head, about midway between snout and anal. Vent midway between snout and base of caudal.

Depth at first ray of anal less than half length of head; thickens at same point over ⅘.

Least depth ¼ of head. Caudal peduncle extremely slender and subterete, suggesting a stickleback. Head smooth. Space above lateral line

behind head covered with small stiff prickles hooked backwards, readily visible as small black specks when skin is dry.

Length, 2 5-6. Color pale brown, irregularly spotted and mottled with darker brown, somewhat as in *Lota*. Pectorals mottled ; belly white ; spines spirally curved, forming half a spiral. The most peculiar characters are the strong spines of the preopercle and the smaller ones below, the carinated back and abruptly contracted body, forming the sub-terete caudal peduncle. The prickles of the skin seem to be more developed than in the other described species.

Genus Uranidea, DeK.

U. hoyi, (*Put.*) *Mss.* Hoy's Bull-Head. For the privilege of including this and the following species and descriptions I am indebted to the kindness of Dr. P. R. Hoy of Racine, Wisconsin :

Description of an adult female taken twelve miles off Racine in forty-two fathoms of water, June 4, 1875, from a very accurate drawing by Mr. A. L. Kumlien : D. VI, 15 ; A. 11 ; V. I, 3; P. 13; C. 12 ; length 2 1-6 in., head $3\frac{1}{4}$; depth $4\frac{1}{4}$. Width of head equals its length. Eye $3\frac{1}{2}$; body short, stout, broad and thick in front, very abruptly compressed behind. Fins all low. P. with lower rays rapidly shortening, reaching just to anal and beyond second dorsal. First dorsal low and small, $\frac{3}{4}$ as long as soft part and connected by membrane at base. Lower jaw unusually projecting.

43. *U. kumlieni*, (*Hoy*) *Mss.* Kumlien's Bull Head. Deep water in Lake Michigan.

D. VI, 17 ; A. 12 ; P. 14 ; V. I, 3; head $3\frac{1}{3}$; depth 6. Body slender as in *boleoides.* Head large and long, its width a little over half its length, depth a little less.

Eye large, equal to snout and $3\frac{1}{2}$ in head, more than two times in interorbital space. Pectoral base cresentic, the fin as long as head ; the lower rays rapidly shortening, reaching second or third dorsal ray and falling just short of anal ; fourth and fifth rays largest. No palatine teeth. Preopercular spine not much hooked, directed upwards and backwards. Vent midway between front of eye and base of caudal. Mouth wide, oblique : maxillary to middle of eye. Lower jaw projecting. First dorsal high, 5-6 second. Second spine longest, almost filamentous ; membrane connecting the dorsals. Caudal peduncle long and slender. Caudal narrow, $\frac{3}{4}$ head. Lat. l. disappears under middle of second dorsal. Dorsal and anal high, their rays projecting. Length three inches. The above description is from one of Dr. Hoy's types.

Genus Pegedichthys, Raf.

44. *P. alvordi*, *Grd.* Common in the Rock river and probably in other streams.

Genus Triglopsis, Grd.

45. *T. thompsoni*, *Grd.* Deep-water Sculpin. Deep water in Lake Michigan.

FAMILY GADIDAE.

Genus Lota, Cuv.

46. *L. lacustris, (Mitch.) Gill.* Eel-pout. Very abundant in Lake Michigan; rare in the Ohio (*Jordan*), and in the Illinois (*Forbes*).

FAMILY GASTEROSTEIDAE.

Genus Eucalia, Jord.

47. *E. inconstans, (Kirt.) Jordan.* Stickleback. Has been found rather common in small tributaries to Lake Michigan, and in Rock river, by Prof. Jordan.

48. *E. pygmaea, (Ag.) Jord.* Occurs in Lake Michigan. (*Jordan.*)

Genus Pygosteus, Brev.

49. *P. nebulosus, (Ag.) Jord.* Many-spined Stickleback. Lake Michigan. (*Jordan.*)

FAMILY ATHERINIDAE.

Genus Labidesthes, Cope.

50. *L sicculus, Cope.* Silverside. This beautiful little species exists in the greatest abundance in the rivers and small streams tributary to the Illinois, in the western and central parts of the state. As far as I have learned, it does not occur in Lake Michigan or its tributaries. Neither does it occur in Rock river. Its centre of abundance seems to be the streams in the more strictly prairie region of the state.

FAMILY CYPRINODONTIDAE.

Genus Fundulus, Lac.

51. *F. diaphanus, (LeS.) Ag.* Barred Minnow. Very abundant about the sandy mouths of tributaries to Lake Michigan, keeping in "schools" in the shallow water near the edge. Occurs in smaller numbers throughout the state, specimens having been taken in nearly all the large streams.

Genus Zygonectes, Ag.

52. *Z. notatus, (Raf.) Jord. (=Z. olivaceus, Stor.)* Top Minnow. Common in the Illinois and smaller tributaries, and in most streams through the state, except in the tributaries of Lake Michigan.

53. *Z. dispar, Ag.* Striped Minnow. A number of specimens are in the state collection from the Illinois river at Pekin, and others from several small tributaries. The following is the description of an average specimen from the Illinois river at Pekin:

Adult about $1\frac{1}{2}$ inches long. Head in length $3\frac{3}{8}$; dorsal 7. Depth in length $4\frac{1}{2}$; anal 9. Lateral line 32 to 34; longitudinal rows 9. Eye longer than snout, 3 in head. Dorsal commencing slightly behind anal; back flattened and plane with the top of the head, sloping from the dorsal to the end of the snout. Caudal peduncle broad, width $\frac{1}{2}$ head. Colors (in alcohol) above and on sides olive; vertebral line and top of head darker; also a crescentic patch of dark brownish extending downward and obliquely backward from the lower posterior part of orbit. Entire head scaly, scales

on the top larger than those on the body. Sides of the scales on the body with longitudinal brown spots, forming very distinct, but rather narrow, brown, longitudinal lines. Along the center of each scale is a row of very fine brown dots, forming minute lines between the heavier ones along the borders of the scales. Beneath, in front of the anal fin, orange yellow.

FAMILY UMBRIDAE.

Genus Melanura, Linn.

54. *M. limi*, (*Kirt.*) *Ag.* Mud Minnow. Exceedingly numerous in prairie sloughs and sluggish streams in the northeastern part of the state. It is also of very rare occurrence in the streams through the state tributary to the Ohio, where it is occasionally taken.

FAMILY ESOCIDAE.

Genus Esox, Linn.

55. *E. nobilior*, *Thomp.* Muskellunge. Rather common in Lake Michigan, and reported to occur in some of the small lakes in the northern part of the state.

56. *E. lucius*, *var. estor*, (*LeS.*) Lake Pike. Very abundant throughout the northern part of the state.

57. *?? E. boreus*, *Ag.* Several specimens, about seven inches long, are in the collection of the writer, from the Fox river at Geneva.

58. *E. salmoneus*, *Raf.* Little Pickerel. Abundant throughout the state.

59. *E. cypho*, *Cope.* A single specimen, in good condition, from the Fox river at Geneva, agrees in every way with Prof. Cope's description of this species (Proc. A. N. S., Phil., 1865, p. 78), with the exception that the bars and dots are obsolete in my specimen. Although Prof. Cope has referred this to a previously described species, yet so marked are its characteristics, that several who have examined my specimen have at once referred it to this species.

60. *E. umbrosus*, *Kirt.* Four specimens from the Fox river at Geneva,—Prof. Cope's Var. A. of this species. (Trans. A., Ph. Soc., 1866.) This species approaches closely to *salmoneus*, and may eventually be reduced to a variety of that species.

FAMILY PERCOPSIDAE.

Genus Percopsis, Ag.

61. *P. guttatus*, *Ag.* Trout Perch. Numerous in Lake Michigan, and of rare occurrence in the larger rivers.

FAMILY SALMONIDAE.

Genus Salmo, Linn.

62. *S. salar*,* *L.* Great Sea Salmon. Fox river at Aurora and near Elgin.

63. *S. quinnat*,* *Rich.* California Salmon. Fox river at Aurora and near Elgin.

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* As this paper is passing through the press, I learn from Dr. W. A. Pratt, of Elgin, that he has taken these two species this summer, at the localities given. I therefore take the liberty of inserting them in this list.—S. A. Forbes.

64. *S. namaycush, Penn.* Lake Trout. Abundant in Lake Michigan.

Genus Argyrosomus, Ag.

65. *A. clupeiformis, (Mitch.) Ag.* Lake Herring. Very abundant in Lake Michigan. The sisco (*A. sisco, Jord.*) undoubtedly occurs in the deep sandy lakes in the northeastern part of the state.

66. *A. nigripinnis, Gill.* Black-fin. Common in deep water in Lake Michigan.

67. *A. hoyi, Gill.* Lake Michigan Sisco. Found in deep water in Lake Michigan.

Genus Coregonus, Linn.

68 *C. albus, LeS.* White-fish. Very abundant in Lake Michigan.

FAMILY HYODONTIDAE.

Genus Hyodon, LeS.

69. *H. tergisus, LeS.* Moon-eye. Common in Lake Michigan and in all the large streams throughout the state.

FAMILY CLUPEIDAE.

Genus Alosa, Cuv.

70. *A. sapidissima, (Wils.) Stor.* Common Shad. Has been introduced into one or two streams in the northern part of the state; but whether it thrives or not, has not been proven.

Genus Pomolobus, Raf.

71. *P. chrysochrous, Raf.* Ohio Shad Found in the Ohio and Mississippi rivers, and sometimes ascends the Illinois. It is also accredited to Lake Michigan by Mr. J. N. Milner.

Genus Dorosoma, Raf.

72. *D. notatum, Raf.* Gizzard Shad. Very common in the rivers in the southern and central parts of the state, and, since the opening of the canal connecting the Chicago river with the Illinois, has found its way, with the preceding, into Lake Michigan.

For some time previous to this date, (December 2nd), the young, from three to four inches long, have been frequenting, in considerable numbers, a "slip" extending from the Chicago river to one of the City Water Works buildings. The attraction to the fishes appears to be the hot water which runs into the "slip" from the Water Works engines. As the fishes swim about in this warm water, they strike the hot stream as it flows in, and many are killed. The opening of the above mentioned canal will have considerable influence upon the distribution of the lake and river fishes, and numerous species will in all probability take advantage of the communication between the Mississippi and the great lakes.

This undoubtedly accounts for the occurrence of *Chaenobryttus gulosus* in Lake Michigan, as well as of the two preceding species.

FAMILY CYPRINIDAE.

Genus Campostoma, Ag.

73. *C. anomalum, (Raf.) Ag.* Stone Roller. Occurs in the greatest abundance throughout the state, although perhaps more rarely in the vicinity

of L. Michigan. This species, as defined by Prof. Jordan (Man. Vert. An., p. 275), exhibits a great amount of variation, and may eventually be separated into two.

Genus Pimephales, Raf.

74. *P. promelas, Raf.* Black-head. Apparently rare. I have examined but three specimens from Illinois; two in the state collection, from Bailey's creek, in Central Illinois, and one in the collection of my friend, Mr. E. L. Rice, obtained near Evanston, in a ditch.

75. *P. milesii, Cope.* Approaches very closely to the preceding species, and one of the central Illinois specimens possesses characters almost intermediate between the two forms.

Genus Hyborhynchus, Ag.

76. *H. notatus, (Raf.) Ag.* Blunt-nosed Minnow. Very numerous throughout the state.

Genus Hybognathus, Ag.

77. *H. nuchalis, Ag.* Blunt-jawed Minnow. Apparently rather uncommon; a few specimens in the state collection from central Illinois

78. *H. argyritis, Grd.* Silvery Minnow. Much more numerous than the preceding. Specimens are in state collection, from central Illinois; and Prof. Jordan informs me that it is common in the larger streams in the Wabash and Ohio valleys.

Genus Ericymba, Cope.

79. *E. buccata, Cope.* Silver-mouthed Dace. Very abundant in the Wabash valley; but no specimens are in the state collection from the western streams tributary to the Mississippi.

Genus Semotilus, Raf.

80. *S. corporalis, (Mitch.) Put.* Horned Dace. Abundant throughout the state.

Genus Ceratichthys, Bd.

81. *C. biguttatus, (Kirt.) Bd.* (=*C. melanotus, Raf.*) Horned Chub. Abundant everywhere.

82. *C. dissimilis, (Kirt.) Cope.* Spotted Shiner. Common in tributaries of the Wabash and Illinois.

Genus Rhinichthys, Ag.

83. *R. nasutus, (Ayres) Ag.* Long-nosed Dace Occurs in tributaries to Lake Michigan. (Jordan.)

84. *R. maxillosus, Cope.* Sharp-nosed Dace. Two specimens in the state collection, from Lake Michigan at Chicago, and another, in my collection, from a small tributary of the lake at Waukegan. This species is at once distinguished from its relatives, by its long slender form, narrow-pointed head and peculiarly shaped head and snout. The body is more nearly cylindrical than usual in this genus.

85. *R. atronasus, (Mitch.) Ag.* Black-nosed Dace. Specimens in the state collection, from tributaries of the Illinois; and others from clear tributaries of Lake Michigan, are in the collection of the author.

86. *R. lunatus*, *Cope.* Fork-tailed Dace. Specimens from Rock river are in Prof. Jordan's collection.

87. *R. meleagris*, *Ag.* A very large number of specimens of this species are in the state collection, from Bailey's creek, McLean county, where Prof. Forbes found them in abundance. Agassiz's description is so incomplete that I insert the following from one of the Illinois specimens. The species is well marked, and may be easily recognized. A few specimens were taken in the Vermilion river:

Head 2 2-5 in length; depth 4¼. Eye small, 5 in head. D. I, 7; A. I, 6. The barbels are long and distinct. The snout projects considerably, overlapping the lower jaw. Dorsal much nearer tail than tip of snout. Upper half of body dark, sharply outlined by the light of the under parts. The dark mottlings are not so profuse as in most of the species. The body is stout, deeper and thicker than in most members of the genus.

Genus Phenacobius, Cope.

88. *P. teretulus*, *Cope, var. liosternus*, *Nelson.* A number of specimens of this form are in the state collection, from small streams in McLean county, where it appears not to be uncommon. The following is the description of the adult:

Head 4⅓ in length; depth 4¾. Eye 4⅓ in head. D. I, 7; A. I, 7; ventrals 8. Lateral line 43 to 45; longitudinal rows 5-4; scales in front of dorsal, 16; length 3 inches. Dorsal in front of ventrals, much nearer snout than caudal. Scales in front of dorsal small. Intestine short, peritoneum pale. Head long; mouth inferior, lateral line first decurved, then straight. Pectorals do not extend to ventrals, ventrals reach vent. Teeth 4-4, hooked. Color olive above, sides bright silvery overlying a plumbeous shade; a small but distinct caudal spot. Thoracic region entirely naked. Lips fleshy, as in the *Catostomidae.*

Genus Hybopsis, Ag.

89. *H. storerianus*, (*Kirt.*) *Ag.* Storer's Minnow. Two specimens in my collection, from Lake Michigan at Chicago. The following is the description of one of the specimens:

Head in length 4¾; depth 4¾; eye in head 3 times, and longer than snout; very large and white. D. I, 8; A. I, 7. Lat. l. 40. Dorsal over ventrals, nearer snout than to caudal; 20 large scales in front of dorsal: lateral line nearly straight; pale above, sides bright silvery; intestine short; peritoneum white. This species presents much the appearance of *amarus*, *Grd.*

90. *H. hudsonius*, (*Clint.*) *Put.* Spawn-eater. Occurs in Lake Michigan. (Jordan.)

91. *H. tuditanus*, *Cope.* Described from Lake Michigan. I have seen no specimens.

92. *H. stramineus*, *Cope.* Very common in creeks through central Illinois, and probably occurs elsewhere, but no specimens have been taken.

93. *H. volucellus*, *Cope.* Specimens have been received from the Rock and Pecatonica rivers, by Prof. H. E. Copeland.

94. *H. fraetensis, Cope.* Specimens in state collection, from Ogle and McLean counties, where it appears to be common.

95. *H. haematurus, Cope.* Tributaries to Lake Michigan. (Jordan.)

Genus Hemitremia, Cope.

96. *H. heterodon, Cope.* Northern Hemitremia. Exceedingly numerous in Lake Michigan and the Calumet river. It also occurs in the Fox river at Geneva.

Genus Chrosomus, Raf.

97. *C. erythrogaster, Raf.* Red-bellied Minnow. Everywhere common in clear streams. Specimens have been examined from all parts of the state.

Genus Phoxinus, Raf.

98. *P. neogaeus, Cope.* New World Minnow. A single specimen obtained in the Fox river at Geneva.

Genus Gila, B. & G.

99. *G. elongata, (Kirt.) Jord.* Red-sided Minnow. Found rather sparingly through the state.

Genus Lythrurus, Jord.

100. *L. diplaemius, (Raf.) Jord.* Red-fin. Rather common through central and southern Illinois, but I have seen no specimens from the northern part, although it may occur.

101. *L. cyanocephalus, Copeland, Mss.* The type specimens were received from the Rock river by Prof. Copeland.

Genus Luxilus, Raf.

102. *L. cornutus, (Mitch.) Jord.* Shiner. Everywhere abundant.

Genus Cyprinella, Grd. (=Plargyrus, Raf.)

103. *C. galacturus, Cope.* Slender Silver-fin. Abundant in Rock-river and tributaries of the Illinois, and south.

Genus Photogenis, Cope.

104. *P. scabriceps, Cope.* Rough-headed Shiner. Tributaries of the Wabash and Ohio. (Jordan.)

Genus Minnilus, Raf.

105. *M. rubrifrons, (Cope) Jord.* Rosy-faced Minnow. Specimens are in the state collection from the Illinois and several of its tributaries, and it also occurs in the Wabash valley.

106. *M. dilectus, (Grd.) Jord.* Delectable Minnow. This species does not seem to be numerous at any place. A few specimens are in the state collection from Lake Michigan, and others from tributaries of the Illinois in McLean county.

107. *M. amabilis, (Grd.) Nelson.* Four specimens of this species are in the state collection from Pine Creek, Ogle county. The following is a description of one of the above specimens—all being alike:

Head 4 in length; depth $4\frac{2}{4}$; eye equals snout, $3\frac{1}{3}$ in head. Dorsal I, 7. Lat. l. 39 or 40. Anal I, 10. Olive above, sides bright silvery over-

laying a well defined plumbeous band, along the lower border of which is the lateral line. Body considerably compressed; color usually dark; a dark dorsal stripe; five or six rows of scales above lateral line; traces of a blackish spot at base of caudal; eye moderate. *M. megalops*, (*Grd.*) *Jord.* is the nearest relative, from which *amabilis* differs by its smaller eye and more pointed head, besides minor characters. *Megalops* is abundant in the rivers of Georgia, Prof. Jordan informs me.

108. *M. rubellus*, (*Ag.*) *Jord.* Rosy Minnow. Exceedingly abundant in Lake Michigan and all the larger streams through the state.

109. *M. dinemus*, *Raf.* Emerald Minnow. Very common in the Fox river at Geneva, and occurs in most of the larger streams through the state.

Genus Notemigonus, Raf.

110. *N. americanus*, (*L.*) *Jord.* Shiner. Abundant everywhere.

Genus Carassius, Nil.

111. *C. auratus*, (*L.*) *Bleeker.* Gold Fish. This species has become naturalized in several of our rivers.

FAMILY CATOSTOMIDAE.

Genus Catostomus, LeS.

112. *C. teres*, (*Mit.*) *LeS.* Common Sucker. Common everywhere throughout the state. A form with a shorter head, and presenting other slight peculiarities occurs in Lake Michigan. This will probably form a variety, but a lack of a sufficient series of specimens has prevented any satisfactory conclusion being reached.

113. *C. hudsonius*, *LeS.* Northern Sucker. A single specimen of this species is in the state collection from Rock river, at Oregon. In this specimen the head is 4 in length; the lat. l. 100: D. 11; A. 7: thus answering closely to Agassiz's *C. aurora.**

Genus Hypentelium, Raf.

114. *H. nigricans*, (*LeS.*) *Jord.* Hammer-head. Abundant everywhere throughout the state.

Genus Erimyzon, Jord.

115. *E. oblongus*, (*Mit.*) *Jord.* Chub Sucker. Common in Lake Michigan and most of the rivers throughout the state. The young of this species have the fins tinged with red, and possess a jet-black lateral band.

116. *E. melanops*, (*Raf.*) *Jord.* Striped Sucker. Common throughout the state. One of the main characters upon which this genus is based proves to be very uncertain, *i. e.*, the absence of the lateral line. In the state collection are specimens of this species which are entirely without a trace of the lateral line; others possess it upon one side only, and others have it upon both sides—generally more or less interrupted, however. Other characters are present which will sustain the separation of this group from related genera, unless new points of connection should be observed.

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*Lake Superior, p. 360, pl. II.

Genus Teretulus, Raf. (=*Moxostoma, Raf.*)

117. *T. duquesnii, (LeS.) Cope.* Red-horse. Common throughout the state.

118. *T. aureolum, (LeS.) Raf.* Golden Mullet. Abundant in Lake Michigan and the Calumet river.

119. *T. anisurus, (Raf.) Nelson.* Carp Mullet. Specimens are in the state collection from the Illinois river.

120. *T. macrolepidotum, (LeS.) Nelson.* Apparently not very common. Specimens in the state collection, from the Illinois and Wabash rivers. (Jordan.)

121. *T. carpio, (Val.) Nelson.* Silvery Mullet. Lake Michigan and the larger rivers. Not common.

122. *T. velatum, (Cope) Nelson.* Common in all the larger tributaries of the Illinois and Mississippi.

Genus Placopharynx, Cope.

123. *P. carinatus, Cope.* Cope's Sucker. Common in the Wabash river (Jordan.)

Genus Ichthyobus, Raf.

There can be no doubt of the propriety of uniting the two genera *Ichthyobus* and *Carpiodes*, since a series of specimens will form so complete a junction between the characters assigned to each that it is impossible to distinguish the dividing line. They have already been united by Prof. Cope, but as *Ichthyobus* has priority over *Carpiodes*, it must stand instead of the latter. The following is the relation in which they were first issued:

Ictiobus, Raf. Ich. Oh., 1820, p. 55, n. subg., type *Amblodon bubalus*, Raf., 1818. *Carpiodes*, Raf. Ich. Oh., 1820, p. 56, n. subg., type *Catost. cyprinus*, LeS., 1818.

124. *I. velifer, (Raf.) Nelson.* Sail Fish. Not uncommon in the Ohio and Mississippi rivers. Specimens in the state collection.

125. *I. difformis, (Cope.) Nelson.* Found in Lake Michigan and the large rivers through the state.

126. *I. bison, (Ag.) Nelson.* Buffalo Carp. Found in the large rivers.

127. *I. thompsoni, (Ag.) Nelson.* Lake Carp. Common in Lake Michigan.

128. *I. carpio, (Raf.) Nelson.* Olive Carp Sucker. A single specimen seen from the Ohio river at Cairo.

129. *I. bubalus, (Raf.) Ag.* Brown Buffalo. Common in all the large rivers through the state.

130. *I. cyanellus*, sp. nov. Blue Buffalo. A number of specimens of this species are in the state collection, from the Illinois river, and in Prof. Jordan's collection, from the Mississippi at St. Louis. The following is the description, taken from several specimens, measuring from 8 to $9\frac{1}{4}$ inches in length:

Head about $3\frac{4}{5}$ in length. Depth $2\frac{1}{3}$ to 2 5-6. Eye $4\frac{4}{5}$ to $5\frac{1}{2}$ in head. Dorsal I, 30 and I, 8. Ventrals 10. Lat. l. 38. Longitudinal rows 7-5 to 7-6. Body compressed, high. Anteriorly broad, compressed be-

hind. Longest ray reaching 18th ray. Pectorals shorter than ventrals, both shorter than head. Anal scarcely reaching caudal; head very short, high and thick; its thickness ¾ length, depth 1 1-5 in length. Mouth quite small, oblique, and overlapped by a slightly projecting snout. Mandible short, 4 in head. Opercle becoming wrinkled with age. Head small, short and thick; muzzle obtuse, conic, not twice the length of eye. Anterior ray of dorsal, in type from Illinois river, slightly nearer snout than base of caudal. In specimens from St. Louis the dorsal is about equi-distant. Color above light steel blue in adults, becoming lighter below. Young lighter with distinct stripes along the rows of scales. Although the species is described from specimens but nine inches long, when fully grown it undoubtedly reaches similar dimensions to its congeners.

Genus Bubalichthys, Ag.

131. *B. niger, (Raf.) Ag.* Buffalo Fish. Rather common in the large rivers throughout the state.

Genus Cycleptus, Raf.

132. *C. elongatus,* (LeS.) Ag. Black-horse. Occurs in the large rivers throughout the state.

FAMILY SILURIDAE.

Genus Ictalurus, Raf.

133. *I. punctatus, (Raf.) Jord.* Channel Cat. Occurs more or less commonly throughout the state.

134. *I. furcatus, (LeS.) Gill.* Great Fork-tailed Cat. Occurs in the large rivers in the western and southern parts.

Genus Amiurus, Raf.

135. *A. confinis, (Grd.) Gill.* Several specimens are in the state collection from the Illinois and tributaries, where it is rather common.

136. *A. pullus, (DeK.) Gill.* Black Bull-head. Several specimens in the state collection from the Illinois and tributaries. Not uncommon.

137. *A. atrarius, (DeK.) Gill.* Northern Bull-head. Common in Lake Michigan and rivers in the northern part of the state.

138. *A. albidus, (LeS.) Gill.* Brown Cat Fish. Our commonest species; abundant throughout the state.

139. *A. vulgaris, (Thomp.) Nelson.* (=*A. dekayi, Gir.* and *A. aelurus, Gir.*) A few specimens have been taken in tributaries of the Illinois in the central part of the state.

140. *A. cupreus, (Raf.) Gill.* Yellow Cat. Common in the Illinois and tributaries, and south.

Genus Hopladelus, Raf.

141. *H. olivaris, (Raf.) Gill.* Mud Cat. Not uncommon in the Ohio and Mississippi rivers.

Genus Noturus, Raf.

142. *N. flavus, Raf.* Very common throughout the state.

143. *N. marginatus, Baird.* Margined Cat. Common in the Wabash valley and south. (Jordan.)

144. *N. exilis*, sp. nov. Slender Cat. Rare. Three specimens were obtained in McLean county by Prof. Forbes, the only ones seen. These specimens present the following characteristics:

Head in length $4\frac{1}{4}$; depth $6\frac{1}{2}$ in length. Eye $4\frac{3}{4}$ in head. Dorsal I, 6; Anal 1, 5. Ventrals 8 or 9. Inter orbital space $3\frac{1}{4}$ in length of head. Dorsal a trifle nearer snout than anal. From snout to dorsal $3\frac{1}{2}$ in total length. Dorsal as high as long, and $1\frac{3}{4}$ in head. Dorsal spine small, $3\frac{1}{4}$ in head. Pectoral spine $2\frac{1}{2}$ in head. Width of head $1\frac{1}{8}$ in length; depth $2\frac{1}{8}$ in length of head. Base of anal $1\frac{1}{2}$ in head.

FAMILY ANGUILLIDAE.

Genus Anguilla, Thunb.

145. *A. vulgaris, var. rostrata, (LeS.) Nelson.* Common Eel. Occurs in Lake Michigan and most of the larger streams through the state, but is far from common anywhere.

FAMILY AMIIDAE.

Genus Amia, Linn.

146. *A. calva, L.* Dog Fish. Abundant throughout the state.

FAMILY LEPIDOSTEIDAE.

Genus Lepidosteus, Lac.

147. *L. osseus, (L.) Ag.* Gar Pike. This is far the most common species in Lake Michigan and the Calumet river, where it is very abundant. It also occurs throughout the state.

148. *L. platystomus, Raf.* Short-nosed Gar. Occurs throughout the state, but is much more abundant in Illinois and south.

Genus Litholepis, Raf.

149. *L. adamanteus, Raf.* Alligator Gar. Common in the Ohio and Mississippi rivers, occasionally straying up smaller rivers into the interior of the state.

FAMILY POLYODONTIDAE.

Genus Polyodon, Lac.

150. *P. folium, Lac.* Duck-billed Cat. Common in central and southern Illinois in the larger streams. Rare in the northern part of the state.

FAMILY ACIPENSERIDAE.

Genus Acipenser, Linn.

151. *A. maculosus, LeS.* Sturgeon. Very abundant in Lake Michigan and the larger rivers throughout the state.

152. *A. rubicundus, LeS.* Lake Sturgeon Very common in Lake Michigan, ascending Calumet river in winter.

Genus Scaphirhynchops, Gill.

153. *S. platyrhynchus, (Raf.) Gill.* Shovel-nosed Sturgeon. Common in the southern part of the state in the Ohio and Mississippi rivers.

FAMILY PETROMYZONTIDAE.

Genus Petromyzon, Linn.

154. *P. niger, Raf.* Small Black Lamprey. Very common in many localities through northern Illinois, ascending small streams in spring from Lake Michigan and the rivers.

Genus Ichthyomyzon, Gir.

155. *I. argenteus, (Kirt.) Grd.* Silvery Lamprey. Lake Michigan and large rivers throughout the state.

156. *I. hirudo, Grd.* A single specimen in the state collection from the Ohio at Cairo.

UPON PARASITIC FUNGI.

BY T. J. BURRILL,

(*Professor of Botany and Horticulture in the Illinois Industrial University.*)

Many doubt the action of microscopic fungi in causing diseases of higher plants and animals. Indeed it has only been in our century, and mostly in the latter part of it, that botanists have distinguished these minute parasites as independent plants. Schleiden (1) in a work written about 1845 said, " I cannot regard the true Uredines, etc., (*Coniomycetes*) as independent plants. Meyen (2) observed the formation of *Uredo maidis* as an abnormal process of cell formation in the interior of the cells of the parent plant; and, in this respect, my own observations on *Elymus arenarius* coincide with his." Unger (3) in 1833 sought to prove that the so-called fungi were changed conditions of diseased tissues; and Fries in a classic work upon fungi, holds similar views.

But the matter is not left undecided The improvements in microscopes, and in methods of tracing the life history of low organisms, have forever settled the doubts in the minds of scientific men. Nothing can be more satisfactory in the way of evidence, than to see with one's own eyes the spores germinating, penetrating the plant tissues, and in due time producing again spores like the original ones. This has been done again and again, and may be seen by any one who will take the trouble to follow, day by day, the development of any of the hundreds always and everywhere at hand. Their

1. Principles of Scientific Botany, London, 1849, p. 151.
2. Ueber die Entwickelung des Getreidebrandes in der Mais-Pflanzen, Weigmans Archiev., 1837, p. 419.
3. Die Exantheme des Pflanzen, Wein, 1833, p. 356.

effects, likewise, may thus be observed, obliging the most skeptical to admit the agency of the parasites in causing the malady to which attention is given.

Probably Prevost first discovered the fact, that the spores of fungi germinate. This was in the first decade of our century. Since then many eminent naturalists have given abundant testimony as to the true parasitism of species, and of their individuality as such. We may, without disparagment to others, mention the names of Leville (4), Tulasne (5), Berkeley (6), and M. Bary (7) as authorities, whose writings have conclusively established the fact that these parasites do cause the maladies attributed to them. Robin (8) and Leidy (9) have published prominent treaties on the vegetable parasites upon living animals.

Observers in this field are now much more numerous than ever before and, having the advantage of the former contributions, are gaining rapidly in the knowledge of kinds and of the injuries caused by these small but in no wise insignificant organisms. Preventives and cures naturally follow investigations of cause. They certainly cannot precede the latter except by accident; hence, if any one feels like asking "What use?" let him possess himself in patience;—in the coming time, man will assert his dominion here as well as elsewhere over the natural world. Something has already been done. The vine disease in Europe has been kept down by the use of sulphur, as are the rose and verbena mildews in green-houses. Sometimes prevention is attained by removing promptly attacked parts, as in the case of the peach-rot, and, as further detailed below, sometimes by destroying the spores of the fungus, as in the bunt of wheat. Cultivators now often unconsciously scatter the germs and ignorantly provide ways and means for their development. The march or migration of a parasite of this kind is sometimes as well marked as that of an injurious species of insect.

Puccinia malvacearum, *Mont.*, affecting cultivated hollyhocks, has been traced from South America through the United States to England and thence to the continent as certainly as the Colorado potato beetle has across our territory. Timely, intelligent action in such cases might avert great disaster. Had this fungus attacked the cotton plant, as it was feared it would, what estimate could be placed upon the loss! What money-value is destroyed in our own state by rust (*Puccinia graminis*, *Pers.*) on wheat, oats, etc.; what discouraging losses by the multitudinous blights upon our cultivated crops, many of which are known, and others supposed to be, caused by parasitic fungi!

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4. Annales des Sc. Naturelles, 1839, etc.; and "Mycologie," and "Uredines," in Dict. d'Hist. Nat., par D'Orbigny.

5. Annales des Sc. Naturelles, 3 ser., tome VII, 1847; 4 ser., tome II, 1854.

6. Introduction to Cryptogamic Botany, London, 1857, p. 261. Outlines of British Fungology, London, 1860, p. 68.

7. Ueber der Brandpilze, 1853. Morphologie und Physiologie der Pilze, 1866, and many papers in Annales des Sciences Naturelles and elsewhere.

8. Historie Naturelle des Vegetaux Parasites qui croissent sur l'homme et sur les animaux vivants, par Charles Robin, Paris, 1853.

9. A Flora and Fauna Within Living Animals, by Joseph Leidy, Smithsonian Cont. to Knowl., Vol. 5, 1853.

Aside from what may be called the practical value of the study, including that which leads to the better understanding of the higher forms of living things, these microscopic creations have many attractions for the student. Nature is always, and to every one, interesting; her pursuit is alluring in the highest degree. To see rare forms men traverse oceans and make pilgrimages over continents; but here are countless unseen living things, under our feet, on every side, in the air we breathe, in the food we eat, on plants, on animals, germinating and propagating under our own finger nails and even in our mouths, possessing a variety of form and structure, often curious and beautiful, never equalled by art and not surpassed in nature. Their wonderful life-histories stimulate inquiry, engage and enchain the attention. He who possesses a microscope, with the ability and opportunity to use it, need never wander from his own door to find an abundance of material awaiting his researches, and entertaining and instructive biographies ready for his pursuit. (10.)

THE PERONOSPORIÆ. (11). Among the pests to the cultivators of fields and gardens, the members of this family maintain a bad pre-eminence. None have attracted more attention from the injuries they do to important plants, and from their peculiar and interesting life-history. Formerly classed in widely different groups on account of their difference in structure, the species have been united from their agreement in development. All produce *conidia*,—naked spores borne upon the tips of erect filaments or *hyphæ*,—which in some cases germinate directly and sometimes give origin to some half-dozen *zoospores*. The latter are small, more or less globular bodies, capable of rapid movements in water by means of two long cilia, which they lash from side to side with astonishing rapidity. They thus swim in a drop of rain or dew some minutes or hours; then, losing the propelling hairs, settle down, and under favorable circumstances germinate like the conidia by protruding one or more slender tubes, which penetrate the tissues of the supporting plant and become the *mycelium* or vegetative threads of the fungus. Besides, through the conidia and their offspring, the zoospores, these particular plants have another method of reproduction. The term *oospore* has been given to a fruit-body found to arise from the conjoined action of two separate cells of the mycelium. This is a sexual process well known among the *algæ* or sea-weeds, but not yet well made out in most fungi, and analogous to the production of seed in flowering plants by the united action of stamen and pistil. The cell producing the oospore is called a *gonosphere* or *oogonium*, and its partner an *antheridium*. The oospores are found on or in the tissues of the host, sometimes only upon one of several plants that the conidia are found upon. Unlike the latter, they lie dormant for some months, but, like them, finally give origin to

10. Cooke's little book on Rust, Smut, Mildew and Mould is an excellent one for a beginner.

11. The plants enumerated in this paper are from collections made by the author between September 21st and and October 16th, 1876, mostly from the area of ground upon which he makes his home. Any collector will perceive that more of the Uredines and other families are omitted than are mentioned.

zoospores which appear identical with those produced by the conidia. The office of the oospore appears to be to pass the winter. The family consists of two genera, *Peronospora* and *Cystopus*. The species of the former have the appearance of moulds, producing conidia singly or in clusters at the tips of the fertile threads, while those of the latter occur as white pustules on leaves, bearing the conidia in moniliform strings, the fertile hyphae or threads having no prominence. Generally the mycelium of both has curious processes, termed *hauptoria*, penetrating the cells of the supporting plant, as shown in Plate II, Fig 7. The threads themselves, when first emitted from the spore as well as when buried and ramified in the tissues, often penetrate the cell through and through, being found at considerable distances from the diseased-looking spots upon which the fruiting threads appear.

Over forty species of *Peronospora* have been described, of which only six are known to exist in the United States. Many others probably await the researches of botanists. Of the six, three, by far the most common ones, are in the present described collection.

Peronospora infestans, Mont., (*Plate II*, *Fig*. 8.) Very common on potatoes and tomatoes. It has also been found on Bittersweet (*Solanum dulcamara*), and even upon a not closely related plant, *Anthoceris viscosa* (12) belonging to the *Scrophulariaceæ*. This is by far the most famous, or infamous, of the species of this genus, causing the well known and often dreaded potato rot. Its history has been often told (13), but a new chapter was added last year by Worthington G. Smith (14), of England. Previously the oospores had not been found as such, and so much search had been made for them that it was quite generally believed that they must exist upon some other supporting plant. Clover, among others, was suspected. The finding of them in the tissues of the leaves and stalks of the potato settled the doubt and bids growers beware of leaving the old potato top to breed the pestilence another year.

P. gangliformis, *Berk*, (*Plate II*, *Fig*. 3.) Common on lettuce and some allied compositæ (*Lactuca altissima* and *Nabalus albus. Farlow.*) Zoospores not observed. Conidia germinating and penetrating young leaves, the tissues usually decaying from above downward until the whole plant is involved and becomes a slushy, putrescent mass. This parasite is especially destructive in forcing-houses. Several hundred dollars worth of lettuce was lost by one propagator here last winter from this fungus (15). The only cure now known is to keep the atmosphere as dry as practicable and remove very carefully the diseased leaves.

P. viticola, *B. & C.* (*Plate II.*, *Figs*. 6 & 7.) Common on grape leaves, and becoming very destructive in this vicinity, worse apparently

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12. Farlow, Synopsis of the Peronosporeae of the United States, Bulletin of the Bussey Institution, p. 426.

13. Smith, Ohio Ag. Report, 1872, Essays, etc., p. 20.

14. Farlow, Gardener's Monthly, Nov. 1875, p. 274. Smith, Ohio Ag. Report, 1862, Essays, etc., p 20.

15. Smith, Gardener's Chronicle, July 17, 1875, p. 69. Quarterly Journal of Microscopic Science, October, 1875.

16. Farlow on the American Grape Vine Disease. Bulletin Bussey Institution, p. 415.

upon the smooth-leaf varieties. The Clintons were nearly or quite killed by it the last two summers. This seems to be a native American, and has often been mistaken for *Erysiphe tuckeri*, *Berk*, which constitutes the vine disease in Europe,—a mistake which has led to an error and disappointment in its treatment. Sulphur proves effectual in case of the *Erysiphe*, but it lives upon the surface of the leaf, not in the tissues, as does our plant. Notwithstanding the continued failures, cultivators still are known who spend their time and money with the sulphur remedy, showing again the importance of the knowledge of the species and their habits. But, unfortunately, a practicable remedy is not now known. The condia produce zoospores, which swim in water some fifteen minutes, then germinate. The oospores are found among the cells of the leaf in autumn. If all the old diseased leaves could be burned, a preventive would be attained.

During the last winter (1874–5) a parasite (Plate I, Figs. 5, 6, 7, 8, 9, 10, 11) was noticed upon many of the plants in the green-house belonging to the Illinois Industrial University. A few of the diseased leaves being taken home for examination, although they were exposed but a few minutes in a room with previously healthy window plants, the same disease soon appeared upon the latter;—a case of the unwitting distribution of disease germs by man. Our real study of this species commenced, however, in October, 1876, when it reappeared in both the localities just named. In one case a box of earth in which some affected plants grew last year (winter of '75–6) was left dry during the summer and some healthy plants replaced in the box in October, 1876. Every care practicable was taken to see that these plants were sound and to exclude infection from any other source. In a week's time there was evidence in abundance of the same parasite. The conidia are now known to germinate when at least one month old, but did they lie dormant all summer? Supposed oospores were found in the petals of Salvias, and figured (Plate I. Fig. 10.) This body is 1-500 in. in diameter, with an apparent hyaline reticulated epispore and a yellowish included spheroid. The fertile hyphæ are dingy or smoky colored, torulose when dry, septate, simple or branched, bearing conidia in dense clusters on the sides and tips of the rigid, blunt extremities. Conidia oval, pappillate, slightly tinted, 1-1800 by 1-2660 in. Believing the plant to be an undescribed *Peronospora*, it was christened *P. fumosa*; but later examination, since the figure was made, makes it questionable about the so-called oospore being such. If not, the plant may belong to the aforetime related genus *Poltactis*, *Link*, in which case its parasitism on living plants is an anomaly. The conidia germinate in water, often emiting two or three tubes. Zoospores not seen. On the leaf the germinating tubes run over the surface or penetrate through the cells to the interior. In about five days from the sowing, the fertile hyphæ appear with their conidia. They arise from the stomata or from the external mycelium. Sometimes the conidial hyphæ do not appear until the leaf or young stem is in an advanced state of decay. On some plants only unhealthy or fallen leaves appear to be affected. Salvias, Geraniums, Centaureas, Senecios and others of diverse orders suffer from its attacks, while as many as twenty kinds have been found living or dead with the fungus upon them. Had time

permitted, I should have been glad to submit this plant to the inspection of others before, perhaps, thus exposing my own incapacity. The only similar figure which I have seen is in Schleiden's Principles of Scientific Botany, London, 1849, Plate 2, Fig. 8. This cannot be the plant.

Of the four recorded United States species of *Cystopus,* three were found. These are exceedingly common on the plants indicated. They do not, however, have the blighting effect of the *Peronosporiœ.* Plants thoroughly dotted with their pustules appeared to survive without great injury. Their microscopic character is so well known to botanists that nothing would have been gained by selecting new specimens to figure, so in my haste copies were selected as indicated. The other figures are from the collection, but none of the plants are more common than these.

Cystopus candidus, Lev., (*Plate I, Figs.* 1, 2, 3, 4.) Common on cruciferous plants, notably here on horse radish and cabbage.

C. cubicus, Mart. On *Ambrosia artemisiæfolia*, the common rag weed.

C. bliti, Bivon. On *Portulaca oleracea* (purslane) and *Amaranthus retroflexus.*

PERISPORIACEI. Notwithstanding the similarity of the names of these families, the plants are very different, as a glance at the plates will show. They, however, agree in their injuries to living plants, constituting very many of the leaf blights of this and other countries. Some of them are most exquisitely beautiful under the magnifier, a thing which the disciples of the development theory of species have not yet accounted for. Their beauty surely does not come from natural or sexual selection. The mycelium runs over the surface of the leaves, never appearing to enter the cellular structure, yet, in some way, deriving nourishment from it. Here applications, as of sulphur, have direct effect. Here, too, the vine and the hop mildews belong. *Conidia* are borne in moniliform strings arising from the *mycelium.* The two together often give the affected leaves a dusty, whitened appearance, as if coated with whitewash. Later the spherical bodies—*conceptacles*—of dark color, as represented in the plates, are formed, sometimes exceedingly numerous, sometimes few and hard to find. The conceptacles have not yet been discovered in the vine disease of Europe. These conceptacles have at length radiating *appendages*, different from the mycelium, of many different forms, though constant within narrow limits in a given species. Inside the usually reticulated conceptacles there are attached to the base one or more *sporangia* or spore-sacks. These are thin and transparent, showing plainly the few or many spores. Sometimes, instead of *sporangia*, multitudes of naked and smaller spore-like forms are found; and sometimes similar ones are contained in a stalked flask-shaped or urn-shaped vessel, as seen in Plate III, Fig. 7. Still other apparent fruit-bodies are found on the mycelium or the appendages of the conceptacles. I do not remember seeing these described, but have often met them and am fully convinced that they belong to the same plants. They are dark-colored like the *Dematiei* species, and of the forms shown in Plate III, Figs. 2b, 2c, 2d, 7f, and Plate IV, Fig. 12. Save in quantity, they are not unlike forms of the black mildews found on thick-leaved plants and known

under the names *Fumago*, *Antennaria*, *Capnodium*, etc., but their positive connection with these plants, positive at least in the case of the specimen figured in Plate III, Fig. 2, of course destroys any sort of specific individuality. I cannot say that they are reproductive bodies, but they certainly look like it. Other plants not distantly related have such forms of fruit. It is probable that the conceptacle, with its contained sporangia, in all these plants, is the result of a peculiar union of specialized cells (17), as in the *Peronosporiæ*.

Sphærotheca castagnei, *Lev.* On *Taraxicum*, *Hop*, *Spirea*, *etc.* To this species we refer with doubt the plant figured on Plate III, Fig. 3, found on *Erechtites hieracifolius*, but the conceptacle is larger (1-245 in.) and the mycelium denser than in any undoubted plants of the species noticed, and the appendages somewhat different. Instead, too, of being distributed over the plant, this is found almost entirely upon the stems and under sides of the leaves, in patches. Appendages (of which there are one to three) colored to a septum. Sporangium one, spores eight, oval, 1-8000 by 1-4300 in.

Phyllactinia guttata, *Lev.*, (*Plate IV, Fig.* 6.) Common on *Fraxinus viridis*. This species is reported to be common on *Quercus*, *Carpinus*, *Berberis*, *Alnus*, *Corylus*, *etc.*

Podosphœra kunzei (?), *Lev.* (*Plate III, Fig.* 2.) On cultivated cherry. This is almost surely not *kunzei*, *Lev.*, but it is the nearest to it of any I know and I am loth to call it new, since so conspicuous and injurious a species could hardly have escaped attention. Leaves of all varieties of cultivated cherries were distorted and caused to fall, from the middle of the summer until autumn. My notes are as follows: Mycelium thin, evanescent; appendages about twelve, colored at base, sometimes septate, simple or but little dichotomously forked; conceptacle black, 1-300 in., gregarious on the upper side of leaves. Sporangium eight-spored. The spore-like forms on the appendages have already been referred to. These were by no means on all the plants, but occurred on this one as shown.

Microsphæria extensa, *C. & P.*, (*Plate IV, Fig.* 2.) On *Quercus rubra* and *Q. palustris* in woods. The upper sides of the leaves are conspicuously whitened.

M. friesii, *Lev.* Very common on *Syringa vulgaris*. The conceptacles are sometimes abundant, but not always. The divided and curled tips of the appendages are very beautiful in perfect specimens.

M. ravenelii, *Berk.*, (*Plate IV, Figs.* 7 *to* 11.) On *Gleditchia triacanthos*. This is certainly the same as my specimen in *Ravenel's exsiccati*, but the mycelium is much more dense. In this respect it surpasses all I have seen. The leaves are very white.

M. elevata, *n. sp.*, (*Plate II, Fig.* 4.) Upper sides of leaves of *Catalpa bignonioides*. Mycelium thin, web-like, rather evanescent. Conceptacles 1-250 in., conspicuously reticulated, raised from the leaf; appendages about twelve, colored at base, often simple, sometimes branched near the base, usually 2 to 4 times dichotomously forked, very long; sporangia four,

17. Sachs' Text Book of Botany, English Ed., 1875, p. 256.

oval, strongly rostrate. This appears to be so distinct from any description given that I have named it as new. Not uncommon.

Erysiphe, ——— (*Plate IV, Fig.* 1.) On *Aster puniceus*. One conceptacle alone found.

E. lamprocarpa, Lev. On Phlox (Old Maid's Pink.)

E. martii, Lk. Very common on leaves and stems of peas. The cultivation of garden peas in late summer and autumn is precluded from the effects of this fungus as much as from the weevil which infests them.

Erotium herbariorum, Lk. On plants in cabinet. Common everywhere.

These are all that were found in these two families, except one of the latter on leaves of *Liriodendron tulipifera*, which was not matured enough to determine. *Botryopium pulchrum* should not have been given among the parasitic plants, as it is only found on decaying herbage. The figure is more slender and the branches longer than Cooke's figure. The species may not be correct. Fear of occupying too much space causes the omission of further notes.

A LIST OF THE ORTHOPTERA OF ILLINOIS.

By CYRUS THOMAS, PH. D.

Fam. 1. FORFICULIDÆ.

1. Forficula aculeata, Scudd.

Found in northern Illinois. It is probable that *Lebia minor*, Linn, may be found in the state, but I am not aware that it has been met with here.

Fam. 2. BLATTIDÆ.

2. Phyllodromia germanica, Linn.

Blatta germanica, Linn. Syst. Nat., II, 688.
Ectobia germanica, West. Introd., I, 515.
Phylladromia germanica, Serv. Orth., 187.

3. Ischnoptera unicolor, Scudd.

Platamodes unicolor, Scudd., Bost Jour. Nat. Hist., VII, 417.
Ectobia lithophila, Scudd., Bost. Jour. Nat. Hist, VII, 418.
Ischnoptera uhleriana, Sauss., Rev. et Mag. Zool., 1862, 169.

4. I. pennsylvanica, Deg.

Blatta pennsylvanica, Deg., 1773, Mem., III, No. 2, Pl. 44, 4.
Ischnoptera morio ?, Burm. Hanb., II, 500.
conloniana, Sauss , Rev. et Mag. Zool., 1862, 169.
Platamodes pennsylvanica, Scudd., Bost. Jour. Nat. Hist., VII, 417.

This is the most common species in the southern part of the state.

5. Periplaneta orientalis, Linn.

Blatta orientalis, Linn., 1745, Faun. Suec., 862.
" culinaris, Deg., Ins., III, 334.
Periplaneta orientalis, Burm. Hanb., II, 504.
Kakerlak orientalis, Serv. Orth., 72.
Stylopyga orientalis, Fisch. de W. Orth. Ross., 70.

6. P. americana, Linn.

Blatta americana, Linn., 1766, Syst. Nat., II, 687.
Kakerlak americana, Brulle, Hist. Nat. Orth., IX, 53.
Periplaneta americana, Burm., Hanb., II, 503.

It is probable that *Ectobia flavocincta*, Scudd., is found in the northern part of the state.

Fam. 3. MANTIDÆ.

7. Stagmomantis carolina, Linn.

Gryllus carolinus, Linn., Amœn Acad., VI, 1763, 396.
Mantis carolina, Linn., Syst. Nat., II, 1767, 691.
" irrorata, Linn., Syst. Nat., II, 690.
" conspurcata, Serv., Orth., 1839, 190.
" inquinata, Serv., Orth., 1839, 191.
" tolteca, Sauss., Rev. et Mag. Zool., XIII, 1861, 127.
Stagmomantis toltecta, Sauss., Bull. Ent. Swiss., III, 1869.
" carolina, Sauss., Mem. Hist. Nat. Mex., IV, 1871, 46.

Found only in the southern part of the state. A species very closely allied to or identical with *Stagmomantis* (*Stagmatoptera*) *minor*, Scudd., is found in the state, but the specimens I have seen were so immature or so imperfect that I could not decide with certainty.

Fam. 4. PHASMIDÆ.

8. Diapheromera femorata, Say.

Spectrum femoratum, Say. Appd. to Long's Exp., 1824, 297. (See Say's Entom, Sec. Ed., 1, 82 & 197.)
Diapheromera sayi, Gray, Synop. Phas., 18, 1835.
Bracteria (Bacunculus) sayi, Burm. Hand., II, 566, 1838.

9. D. velii, Walsh, Proc. Ent. Soc. Phila., III, 410.

10 ? Anisomorpha buprestoides, Stoll.

Spectrum bivittatum, Say, Am. Ent., Sec. Ed., I, 82.
Phasma buprestoides, Stoll, Rep. des Spec., 68, pl. XXII1, p. 87.
Anisomorpha buprestoides, Gray, Synop. Phas., 19.

This species is included with much doubt. It has been observed in Kentucky, and although I have no Illinois specimen at hand, I feel quite sure that I have seen a specimen captured in the extreme southern part of this state.

FAM. 5. ACRIDIDÆ.

Sub-fam. ACRIDINÆ.

Group TRYXALINI.

11. Tryxalis brevicornis, LINN.

Gryllus (Acrida) brevicornis, Linn., Syst. Nat., II, 692.
Truxalis brevicornis, Fabr.. Ent. Syst., II, 27.
(*f.*) viridulus, Pal. Beauv., Ins. Orth., 81, Pl. 3, Fig. 4.
(*m.*) notochlorus, Pal. Beauv., Ins. Orth., 80, Pl. 3, Fig. 3.
Acridium ensicornu, Deg. Ins., 3, 499, Pl 42, Fig. 7.
Opsomala punctipennis, Thos., Trans. Ill. St. Ag. Soc., V, 447.
Pyrgomorpha brevicornis, Walk., Cat. Dermap. Salt., III, 500.
punctipennis, Thos., Synop. Acrid., 68.

I have found this species at but one place in Illinois, and that a very small area in Jackson county.

12. T. viridis, SCUDD.

Chloealtis viridis, Scudd., Bost. Jour. Nat. Hist., 1862, VII, 455.
Opsomala brevipennis, Thos., Trans. Ill. Ag. Soc., V, 451.
Chrysochraon viridis, Thos., Synop. Acrid., 71.
Truxalis angusticornis, Stal., Recens. Orth., I, 105.

Found throughout the state.

13. T. conspersus, HARR.

Chloealtis conspersa, Harr. Rep., Ed. 1862, 184.
abortiva, Harr. Rep., Ed. 1862, 184.
Stenobothrus melanopleurus, Scudd., Bost. Jour. Nat. Hist., 1862, VII, 456.
Chrysochraon conspersum, Thos., Synop. Acrid., 76.

Occasionally met with in various parts of the state; not common. This and the preceding (*T. viridis*) are in all probability varieties of one species.

14. Stenobothrus admirabilis, UHLER.

(*f.*) St. admirabilis, Uhler., Proc. Ent. Soc. Phila., 1864, 553.
(*m.*) Thos., Synop. Acrid., 85, (1873.)

Found throughout the state, but not abundant.

15. St. maculipennis, SCUDD., Bost. Jour. Nat Hist, 1862, VII, 458

Found in the northern portion of the state. *St. aequalis* and *St. propinquans* are but varieties of this species.

16. St. curtipennis, HARR.

Locusta curtipennis, Harr. Cat. Ins. Mass., 56.
Chloealtis curtipennis, Harr. Rept., Ed. 1862, 184, Pl. 3, Fig. 1.
Stenobothrus longipennis, Scudd., Bost. Jour. Nat. Hist., VII, 457.

Quite common, especially in the northern and central parts of the state, the long-winged variety appearing to predominate in the central part of the state, at least as far as my observations have extended.

Group Oedipodini.

17. Stetheophyma gracilis ?, Scudd.

Arcyptera gracilis, Scudd., Bost. Jour. Nat. Hist., VII, 463.
Stetheophyma gracilis, Thos., Synop. Acrid., 99.

I have seen but a single specimen of this genus captured in Illinois; it was taken in the extreme northern portion. I saw it but for a short time and am not positive as to the species.

18. Tragocephala viridifasciata, Harr.

1. *Variety virginiana*, Fabr.

Gryllus virginianus, Fabr. Syst. Ent., 291.
(Locusta) virginianus, Goeze. Ent. Beitr., II, 106.
Acridium virginianum, Oliv. Encyc. Meth., Ins. VI, 225.
(Oedipoda) virginianum. DeHaan. Bijdr. Kenn. Orth., 143.
Oedipoda virginiana, Burm. Hanb. Ent., II, 645.
Gryllus (Locusta) viridifasciatus, Goez. Beitr., II, 115.
Acrydium viridifasciatum, Deg., Mem., III, 498.
Locusta viridifasciata, Harr., Cat. Ins., 56.
(Tragocephala) viridifasciata, Harr. Rep., Ed. 1862, 182.
Gomphocerus viridifasciatus, Uhler, in Harr., Ed. 1862, 181.
Tragocephala viridifasciata, Scudd., Bost. Jour. Nat. Hist, VII, 461.
Gryllus (Locusta) chrysomelus, Gmel, Linn. Syst. Nat., IV, 2086.
Acridium marginatum, Oliv. Encyc. Meth., Ins. VI, 229.
hemipterum, Pal. Beauv., Ins., 145.

2. *Variety infuscata*, Harr.

Locusta (Tragocephala) infuscata, Harr. Rep., Ed. 1862, 181.
Gomphocerus infuscatus, Uhler, in Harr. Rep., 3d Edn., 181.
Tragocephala infuscata, Scudd., Bost. Jour. Nat. Hist., VII, 466.

3. *Variety radiata*, Harr.

Locusta radiata, Harr. Cat., 56.
Tragocephala radiata, Harr. Rep., Ed. 1862, 183.
Gomphocerus radiatus, Uhler, in Harr. Rep., 181.

The green variety (*virginiana*) is very common throughout the state, the female being apparently more abundant than the male; on the other hand, the male of the dusky or brown variety (*infuscata*) appears to be much more abundant than the female of that variety. It is this male that greets us first in the spring with his crackling notes. Variety *radiata* is occasionally met with in the southern and central parts of the state, and probably in the northern sections also.

19. Tomonotus sulphureus, Fabr.

1. *Variety sulphureus*, Fabr.

Gryllus sulphureus, Fabr. Syst. Ent., II, 59.
(Locusta) sulphureus, Gmel. Linn., Syst Nat. I, 2079.
Acridium sulphureum, Oliv. Encyc. Meth. Ins., VI, 227.
Oedipoda sulphurea, Burm. Hanb. Ent., II, 643.
Locusta sulphurea, Harr. Rep., 177, Pl. I, Fig. 6.
Tomonotus sulphureus, Sauss.,Rev. et Mag. Zool ,XIII, 1861, 321.
Arphia sulphurea, Stal. Recens. Orthop., I, 119.

2. *Variety xanthopterus*, Burm.

Oedipoda xanthoptera, Burm. Hanb. Ent., II, 643.
Acridium xanthopterum, De Haan. Bijdr. Kenn. Orth., 143.
Tomonotus xanthopterus, Thos. Synop. Acrid., 105.
Arphia xanthoptera, Scudd. Geol. Surv. N. Hamp., I, 377.

3. *Variety carinatus*, Scudd.

Oedipoda carinata, Scudd. Trans. Am. Ent. Soc., II, 306.
Tomonotus carinatus, Thos. Synop. Acrid., 106.

The first and second varieties (*sulphureus* and *xanthopterus*) are found, I believe, throughout the state, though the former largely predominates, as far as my observations have gone; but there is such a complete gradation from one to the other in all the characters by which they are supposed to differ, that very often it is impossible to tell to which a specimen belongs. The variety *carinatus* is found only in the north-west part of the state.

20. T. tenebrosus, Scudd.

Oedipoda tenebrosa, Scudd. Hayden's, Geol. Surv. Neb., 251.
Tomonotus pseudo-nietanus, Thos. Proc. Acad. Nat. Sci. Phila., 1870, 80.
tenebrosus, Thos. Syn. Acrid., 107.
Arphia sanguinaria, Stal, Recens. Orth., I, 119,
tenebrosa, Scudd. Bul. U. S. Geol. Surv., 1876.

This is occasionally seen in the extreme north-western part of the state; I have seen but one specimen collected in the state, and that was by Miss E. A. Smith, of Peoria.

21, Spharagemon aeqale, Say.

Gryllus aequalis, Say., Jour. Acad. Nat. Sci. Phila., IV, 307.
Locusta aequalis, Harr. Rep., 583
Oedipoda aequalis, Erichs., Archiv. f. Nat., IX, 230.
Trimerotropis aequalis, Scudd., Geol. Surv. N. Hamp., I, 377.
Spharagemon aequale, Scudd., Proc. Bost. Soc. Nat. Hist., XVII, 1874–5.

This species is found throughout the greater part of the state, yet

many Illinois specimens referred to it do not belong to the species. I think *Trimerotropis verruculata*, although placed by Mr. Scudder in a different genus, is in fact but a variety of this species; yet as there is some doubt on this point I give them as distinct.

22. S. collare, Scudd.

Oedipoda collaris, Scudd., Geol. Surv. Neb., 250.
Spharagemon collare, Scudd., Proc. Bost. Soc. Nat. Hist., XVII, 1874–5.

Has been taken in the northern part of the state, but I am inclined to think it is very rare.

23. Trimerotropis verruculata, Kirby.

Locusta verruculata, Kirby, Faun. Bor. Am. Ins., 250.
latipennis, Harr. Rep., 179.
Acridium verruculatum, De Haan, Bijdr. Kenn. Orth., 250.
Oedipoda latipennis, Uhler., Harr. Rep., 178.
Trimerotropis verruculata, Scudd., Geol. Surv, N. Hamp., 1, 377.

Limited chiefly to the northern section, but has been obtained in the southern.

24. Encoptolophus sordidus, Burm.

Oedipoda sordida, Burm., Hanb. Ent., II, 643.
Acridium (Oedipoda) sordidum, De Haan. Bijdr. Kenn. Orth., 143.
Locusta nebulosa, Harr., Rep., 181.
Oedipoda nebulosa, Erichs, Archiv. f. Nat. II, 230.
Locusta periscelidis, Harr, Cat., 56.
Tragocephala sordida, Stal., Recens. Orth., I, 119.
Encoptolophus sordida, Scudd., Proc. Bost. Soc. Nat. Hist., XVII, 1874–5.

Found occasionally throughout the state.

25. Oedipoda carolina, Linn.

Gryllus (Locusta) carolina, Linn, Syst. Nat. I., 701.
carolinus, Fab., Ent. Syst., II, 58.
Acrydium carolinum, Deg., Ins., III, 491, Pl. 41, Figs. 2 & 3.
carolinum, Pal. Beav., Ins., 147, Pl. 4, Fig. 6.
Locusta carolina, Harr. Rep., 176, Pl. 3, Fig. 3.
caroliniana, Catesby, Nat. Hist. Car., II, 89, Tab. 89.

Common throughout the state.

26. Oe. neglecta, Thos.

Oedipoda neglecta, Thos., Proc. Acad. Nat. Sci., Phila., 1870, 84.
Hippiscus neglectus, Scudd, Bull. Geol. Surv. Terr., Vol. II, No. 3, 1876, 264.

I have captured this species in southern Illinois, but think it is very rarely found here.

27. Oe. belfragii, Stal, Recens. Orth., I, 129.

As this species is described by Stal as new and as coming from Illinois, I give here his description in full for the benefit of Illinois naturalists :

" Fuscous-brown ; the head variegated with cinereous ; carina of the head and of the posterior femora, also the posterior margin of the pronotum sprinkled with black ; antennae annulated with fuscous. Pronotum with the posterior margin acute-angled ; crest somewhat prominent, profoundly incised between the lobes. Elytra pale grayish-brown, somewhat translucent toward the apex, where they are also clouded with fuscous. Wings pale yellow at base, with a broad black band across the disk arcuate and narrowed internally ; apex transparent, with fuscous veins. Anterior legs sub-annulated with fuscous ; posterior femora with the fascia and apex black, the inferior margin and exterior side hairy ; posterior tibiae pale yellowish, fuscous at the base, spine tipped with black, hairy. Female, length, 25 millimeters. Illinois.

" In the structure of the head and pronotum similar to *Oe. carolina*, but differs in being smaller, the elytra and wings less ample, and the former less densely reticulated ; the pronotum behind the middle being sub-alutaceous ; and in the color of the wings. The posterior angle of the lateral lobe of the pronotum rounded."

I am unacquainted with this species, and think the locality given is a mistake, or that it is a variety of some of the trans-Mississippi species which occasionally visit Illinois.

28. Mestobregma? cincta, Thos

Oedipoda cincta, Thos., Proc. Acad. Nat. Sci., Phila., 1870, 80.

I have taken a few specimens of this species in southern Illinois, but it is by no means common. I place it in this genus with doubt.

29. Hippiscus corallipes, Hald

Oedipoda corallipes, Hald , Stansb. Rep. Salt Lake, Pl. X, Fig. 2.
Hippiscus corallipes, Scudd. Bull. Geol. Surv. Terr., 1876, II, 264.
Oedipoda rugosa, Scudd. Bost. Jour. Nat. Hist., VII, 469.
Hippiscus rugosus, Scudd. Geol. Surv. N. Hamp., I, 377.
Oedipoda paradoxa, Thos. Geol. Surv. Terr. 1871, 457.
(Hippiscus paradoxus.)
Oedipoda haldemanii, Scudd. Geol Surv., Neb., 251.
Hippiscus haldemanii, Scudd. Bull. Geol. Surv. Terr., 1876, II, 264.

A close study of these forms for a number of years has satisfied me that they are all varieties of one species The specimens found in Illinois are chiefly of the varitey *rugosus ;* but I find some which approach very near to *paradoxus*, with red or partly red wings.

30. Hip. discoideus, Serv.

Oedipoda discoidea, Serv. Hist. Orthop., 724.
Acridium tuberculatum, Pal. Beauv., Ins., 145, Pl. 4, Fig. 1.
Hippiscus discoideus, Stal. Recens. Orth., I, 121.

This is occasionally met with in the extreme southern part of the state, Union county being as far north as I have positive evidence of its being found.

31. Hip. phoenicopterus, Germ.

Locusta apiculata, Harr. Cat., 56.
corallina, Harr. Rep., 176.
Acridium phoenicopterum, De Haan. Bijdr. Kenn. Orth , 144.
Oedipoda phoenicoptera, Germ., Burm. Handb. Ent., II, 643.
obliterata ? Germ., Burm. Handb. Ent., II, 643.
corallina, Erichs. Archiv. f. Nat., IX, 229.
Hippiscus phoenicopterus, Scudd. Geol. Surv. N. Hamp. I, 377.

Found occasionally in various parts of the state; but by no means common.

32. Camnula pellucida, Scudd.

Oedipoda pellucida, Scudd. Bost. Jour. Nat. Hist., VII, 472.
atrox, Scudd. Geol. Surv. Neb., 253.
Camnula tricarinata ? Stal. Recens. Orth., I, 120.
pellucida, Scudd. Geol. Surv. N. Hamp., I, 378.

I have never, that I am aware of, met with this species in Illinois, but find this locality given by Mr. Scudder in the Geological Survey of New Hampshire.

Group Acridini.

33. Pezotettix unicolor, Thos. Synop. Acrid., 151.

Found in southern, and probably in central, Illinois.

34. Pez. minutipennis, sp. nov.

Female. Head short, eyes approximate above; the vertex very narrow between them, suddenly expanding to lateral angles just in front of them, slightly, sometimes scarcely, sulcate. Face, seen from the side, oblique and arcuate; frontal costa somewhat prominent, continuous nearly or quite to the clypeus, sides parallel, not, or but very slightly, sulcate. Pronotum cylindrical, the median carina distinct, though it is but a very slender line; lateral carina wholly obliterated; sides nearly parallel, expanding very slightly posteriorly; anterior margin squarely truncate; posterior margin truncate, with a slight notch at the middle, sometimes scarcely distinct; the posterior transverse incision is situated much behind the middle, reducing the posterior lobe to but one-third the length of the pronotum; the posterior lateral angle rounded, and the margin from thence up to the middle rounded

with no inward curve or notch except the one at the middle of the dorsum. Elytra minute, not meeting on the back, the space between them being more than the width of one of them; narrow, spatulate, width about one-third the length; extending over the second abdominal segment; longitudinal nerves prominent and similar. Abdomen somewhat prominent and carinated at the base, but suddenly decreasing in size posteriorly, so that near or a little beyond the middle it becomes cylindrical. Anterior femora slender; posterior femora about as long as the abdomen; upper carina distinct, and the upper external angle distinct and somewhat sharply defined; the tibiae distinctly expanding below. Prosternal spine broad at base, transverse, bluntly rounded at the tip.

Color. Head and thorax varying in different individuals from dull greenish-white to brown, with a clearly defined shining black line extending, on each side, from the eye to the posterior margin of the pronotum. Posterior femora bright pea-green, unspotted, except the tip, which is black; tibiae greenish, with the spines black.

Male. Much smaller than the female; eyes very prominent, and so closely approximate above that the portion of the vertex between them is reduced to a mere thread; the antennae comparatively large and reaching back to about the tip of the second abdominal segment. Tip of the abdomen strongly curved upward; cerci somewhat elongate, slender, and narrowed in the middle; tip of the last ventral segment somewhat conical, entire. Face quite oblique and arcuate.

Color (of the single specimen.) Face and disk of the pronotum dull ash-brown; cheeks and space of the pronotum below the black stripe pale ash-brown or rufous; posterior femora greenish-yellow, deeply tinged with bright-rufous above.

Dimensions.—Female, length .90 inch; male, length .65 inch.

Two females and one male, taken by Prof. Forbes, of Normal, in September.

I have given this as a distinct species, but confess I have very little expectation that most of the recently described western species of *Pezotettix* and *Caloptenus* will withstand the test of future investigations. It is more than probable that this will prove to be but a variety of Mr. Smith's *Pez. manca.* This species, or variety, as it may prove to be, appears to be an intermediate link between *Pez. manca*, Sm., and *Pez. alba*, Dodge, the former of Maine, the latter of Nebraska.

35. Pez. scudderi, Uhler, Proc. Ent. Soc. Phila., II, 555.

This is given on the authority of Mr. Uhler, who states that he received it from Rock Island, through Mr. Walsh. I am not acquainted with it, but have before me some specimens received from Prof. Forbes, taken at Normal, which I am inclined to refer to it. They differ from

Uhler's description as follows: The black stripe on the side of the female pronotum is distinct and broad; whitish spots on the metathorax distinct in the male; posterior femora yellow or greenish-yellow, with distinct oblique dark bands; posterior tibiae pale.

36. Pez. viola, sp. nov.

Female. Rather large and robust, caloptenoid in appearance, and resembling somewhat *Pez. dodgei*. Vertex and frontal costa not, or but slightly, sulcate. Pronotum with the median carina slight; lateral carinae somewhat distinct; sides flattened; posterior margin rounded; posterior lateral margins with a distinct inward curve or rounded notch at the humerus, the portion below the notch perpendicular. Elytra ovate-lanceolate, the externo-median nerve distinct, not always meeting at the base, but overlapping more or less toward the apex; varying in length from about one-third to more than one-half that of the abdomen.

Color. Varying from a dull olive-brown to ash-brown. Head and thorax brown; elytra with the upper (or inner) half pale brown, lower (outer) half dark-brown or black, one or two dots sometimes broken off the black at the tip; posterior femora reddish with oblique brownish bands; posterior tibiae rufous.

Dimensions. Length 1. to 1.1 inch.

Central and southern Illinois.

37. Caloptenus femur-rubrum, Deg.

Acrydium femur-rubrum, Deg. Ins., III, 498, Pl. 2, Fig 5.
femorale, Oliv. Encyc. Meth. Ins., VI, 228.
Gryllus (Locusta) erythropterus, Gmel. Linn. Syst. Nat., I, 2086.
Caloptenus femur-rubrum, Burm. Handb. Ent., II, 638.
Pezotettix (Melanoplus) femur-rubrum, Stal. Recens. Orthop, I, 79

Our most common species; found throughout the state.

38. C. atlantis, Riley, 1st Rept., 1875, 169.

This is but a variety of the preceding species, and appears to be an intermediate link betwean *C. femur-rubrum* and *C. spretus;* but in some respects approaches *C. occidentalis*.

39 ? C. spretus, Thos. (The Rocky Mountain Locust.)

Acridium spretum, Thos. Trans. Ill. Ag. Soc., V, 450.
Caloptenus spretus, Thos. Synop. Acrid, 164.

A few stray specimens have perhaps been captured in Illinois, and hence I include it with a mark of doubt prefixed.

40. Acridium differentiale, Thos., Trans. Ill. Ag. Soc.; V, 450.

Cyrtacanthacris differentialis, Walk. Cat. Dermap. Salt., IV, 610.
Caloptenus differentialis, Thos. Proc. Acad. Nat. Sci. Phila., 1871.

Common throughout the state, and has occasionally been seen migrating.

41. Acridium rubiginosum, Scudd.

Acridium rubiginosum, Scudd., Bost. Jour. Nat. Hist., VII, 467.
damnificum, Sauss. Rev. et Mag. Zool., XIII, 1861, 164.

Occasionally met with in southern Illinois, in the oak regions.

42. A. emarginatum, Scudd. Geol. Surv. Neb., 240.

I have seen but a single Illinois specimen, which was captured by Prof. Forbes, at Normal.

43. A. americanum, Drury.

Gryllus americanus, Drury, Ill., II, 3, 128, Pl. 49, Fig. 2, 1770.
succinctus, Linn. Syst. Nat.., 12th Ed., I, 699, 1767.
serialis, Thunb. Mem. Acad. Pet., V, 241, 1815.
Locusta tartarica, West. in Drury Ill., I, 121.
Acridium americanum, Scudd., Bost. Jour. Nat. Hist., VII, 466.
rusticum, Glov. Ill., Pl. 1, Fig. 15.
(Schistocerca) americanum, Stal. Recens. Orth., I, 66.
ambiguum, Thos. Synop. Acrid., 173.

Common in southern Illinois, and occasionally found as far north as Normal and Champaign.

Sub-fam. Tettiginae.

Group Tettigini.

44. Tettix ornata, Say.

Acrydium ornatum, Say. Am. Ent., I, 10, Pl. V, Fig. 1.
Tetrix arenosa, Burm. Handb. Ent., II, 659.
dorsalis, Harr. Rep., 186.
quadrimaculata, Harr. Rep., 186.
bilineata, Harr. Rep., 186.
sordida, Harr. Rep., 187.
Tettix ornata, Scudd. Bost. Jour. Nat. Hist., VII, 474.

45. Tettigidea lateralis, Say.

Acrydium laterale, Say. Am. Ent., Pl. V, Figs. 2 & 3.
Tetrix lateralis, Harr. Rep., 187.
Tettigidea lateralis, Scudd. Bost. Jour. Nat. Hist., VII, 477.

46. T. polymorpha, Burm.

Tetrix polymorpha, Burm. Handb. Ent., II, 659.
parvipennis, Harr. Rep., 187, Fig. 82.
Tettigidea polymorpha, Scudd. Bost. Jour. Nat. Hist., VII, 477.

EXPLANATION OF THE PLATES.

ILLINOIS CRUSTACEA.

1, 2, 3, 4, 5, 6, 7, *Crangonyx mucronatus*, Forbes.

1. Head of female, with pedicels of antennae.
2. Posterior abdominal segments of male, with their appendages.
3. One of 1st pair of hands of male.
4. One of 2d pair of hands of male.
5. Telson and last pair of stylets of female.
6. One of 1st pair of hands of female.
7. One of 2d pair of hands of female.

8, 9, 10, 11, *Asellus brevicauda*, Forbes.

8. Hand of male, × 20.
9. One of 1st pair of genital plates of male, × 38.
10. One of 2d pair of genital plates of male, × 19.
11. One of caudal stylets.

12, 13, 14, 15, 16, *Asellus intermedius*, Forbes.

12. Hand of male, × 45.
13. Hand of female.
14. Last segment of abdomen, with caudal stylets, × 17.
15. One of 1st pair of genital plates of male, × 38.
16. One of 2d pair of genital plates of male, × 38.

17, 18, *Asellus communis*, Say.

17. One of 1st pair of genital plates of male, × 18.
18. One of 2d pair of genital plates of male, × 18.

19, 20, *Asellus stygius*, Pack.

19. One of 1st pair of genital plates of male.
20. One of 2d pair of genital plates of male.

21, 22, 25, *Eubranchipus serratus*, Forbes.

21. Abdomen, × 3.
22. Frontal appendage of male, × 10.
25. Claspers of male, from before, × 6.

23, 26, 27, 31, *Canthocamptus illinoisensis*, Forbes

23. One of 5th pair of legs of female.
26. One of anterior maxillipeds, × 250.
27. One of 3d pair of legs of male.
31. One of posterior maxillipeds.

24, 28, 29, 30, *Diaptomus sanguineus*, Forbes.

24. One of posterior maxillipeds.
28. One of anterior maxillipeds, × 66.
29. 5th pair of legs of male.
29a. Tip of inner ramus of left leg.
30. One of 5th pair of legs of female.

PARASITIC FUNGI.

PLATE I.

1, 2, 3 & 4, *Cystopus candidus*, Lev.

1. Portion of cabbage leaf with spots and holes caused by fungus.
2. Conidia, magnified 360 diam. After Cooke.
3a. Oogonium; 3b, antheridium; 3c, oospore, magnified 400 diam.
4. Oospore (the developed oosphere) ruptured, exhibiting zoospores, magnified 400 diameters. After De Barry.
4a. Free zoospores from oospore. 3 & 4 after De Barry.

5, 6, 7, 8, 9, 10 & 11, *Undetermined Parasite on Green-house Plants.*

5. Portion of petiole of geranium, with fungus; natural size.
6. Fertile hyphæ and conidia, magnified about 175 diam.
7. Conidium magnified 650 diam
8. Conidium twelve hours after sowing in water, outer coat ruptured and the inner protruding in the form of a tube, magnified 320 diam
9. Same conidium, thirty hours after sowing, magnified 325 diam.; germinating tube issuing from two points.
10. Supposed oospore, (see text) magnified 390 diam.
11. Longitudinal section of stem of Achyranthus, with mycelium, especially following the vascular bundles, a. Also seen penetrating cells of pith, c.

PLATE II.

1. *Melanispora populina*, Lev. a, Portion of leaf of Populus monilifera, natural size; b, Summer spores.
2. *Botryopium pulchrum (?)* Corda. Magnified about 75 diam.

3. *Peronospora gangliformis*, Berk. Lettuce mould.
4. *Microsphæria elevata*, n. sp. On leaves of Catalpa bignonioides; magnified 75 diam.
5. Sporangia of same.
6. *Peronospora viticola*, B. & C. On grape leaves.
7. Mycelium of same, with haustoria in pith of young stem.; magnified 350 diam.
8. *Peronospora infestans*, Mont. Magnified 350 diam.

PLATE III.

1. Section of leaf of Pinus austriaca, with *Pestalozzia* ———. Magnified 20 diam. The leaves are probably dying from some other fungus.

1a. Spores of same, magnified 85 diam.

2. *Podosphæra kunzei* (?) Lev. On cultivated cherry leaves; magnified 75 diam.

2a. Sporangium of same.

2b. Macrosporium-like or capnodium-like bodies on appendages.

2c. Appendage having moniliform divisions.

2d. Similar to c. Found mostly on mycelium.

3. *Sphærotheca castagnei* (?) Lev. On Erechtites hieracifolus; magnified 75 diam.
4. Sporangia of same.
5. *Rhytisma acerinum*, Fr. On leaf of Acer dasycarpum; natural size.
6. Vertical section of same. c. Asci with young spores.
7. Plycinidia of an Erysiphe on Verbena urticifolia.

7f. Macrosporium-like forms found with latter.

PLATE IV.

1. *Erysiphe*, ———. On Aster puniceus.
2. *Microsphæria extensa*, C. & P. On Quercus rubra; magnified 75 diam.
3. Appendage, magnified 300 diam.
4. Ruptured conceptacle of same; a. sporangia.
5. Triposporium-like bodies on same mycelium.
6. *Phylactinia guttata*, Lev. On Fraxinus viridis.

7, 8, 9, 10 & 11. *Microsphæria ravenelii*, Berk. On Gleditchia triacanthos.

12. Macrosporium-like bodies, with *Microsphæria fresii*, Lev. On leaves of Syringa vulgaris.

THE TREE IN WINTER.

PLATE I.

1. Aesculus glabra, Willd. Buckeye.
2. Acer saccharinum, Wang. Sugar maple.
3. Acer dasycarpum, Ehrh. Soft maple.

4. Negundo aceroides, Moench. Box elder.
5. Staphylea trifolia, L. Bladder nut.
6. Euonymus atropurpureus, Jacq. Burning bush.
7. Sambucus canadensis, L. Elder.
8. Fraxinus americana, L. White ash.
9 Fraxinus pubescens, Lam. Red ash.
10. Fraxinus viridis, Michx., f. Green ash.
11. Fraxinus sambucifolia, Lam. Black ash.
12. Fraxinus quadrangulata, Michx. Blue ash.
13. Viburnum lentago, L. Sheep berry.
14. Viburnum dentatum, L. Arrow wood.
15. Cornus paniculata, L'Her. Panicled cornel.
16. Lonicera flava, Sims. Yellow honeysuckle.
17. Tecoma radicans, Juss Trumpet-creeper.
18. Catalpa bignonioides, Walt. Indian bean.
19. Cephalanthus occidentalis, L. Button bush.
20. Rhamnus laceolatus, Pursh Buck-thorn.
21. Horizontal cut of the bud of Fraxinus sambucifolia.
22. Horizontal cut of the bud of Acer dasycarpum.
23. Horizontal cut of the bud of Staphylea trifolia.
24. Horizontal cut of the bud of Cornus paniculata.
25. Horizontal cut of the bud of Euonymus atropurpureus.

PLATE II.

1. Quercus alba, L. White oak.
2. Quercus macrocarpa, Michx. Burr oak.
3. Quercus bicolor, Willd. Swamp white oak.
4. Quercus prinus, L. (Var. acuminata, Michx.) Chestnut oak.
5. Quercus imbricaria, Michx. Shingle oak.
6. Quercus coccinea, Wang. Scarlet oak.
7. Quercus rubra, L. Red oak.
8. Quercus nigra, L. Black-jack oak.
9. Populus monilifera, Ait. Cottonwood.
10. Populus heterophylla, L. Downy poplar.
11. Populus grandidentata, Michx. Large-toothed aspen.
12. Populus tremuloides, Michx. Aspen.
13. Corylus americana, Walt. Hazlenut.
14. Fagus ferruginea, Ait. Beech.
15. Ostrya virginica, Willd. Hop hornbeam.
16. Carpinus americana, Michx. Hornbeam.
17. Juglans cinerea, L. Butternut.
18. Juglans nigra, L. Black walnut.
19. Carya alba, Nutt. Hickory.
20. Carya tomentosa, Nutt. Mockernut.
21. Carya olivaeformis, Nutt. Pecan.
22. Carya amara, Nutt Bitternut.
23. Liquidambar styraciflua, L. Sweet gum

PLATE III.

1. Gymnocladus canadensis, Lam. Coffee-bean tree.
2. Amorpha fruticosa, L. False indigo.
3. Platanus occidentalis, L. Sycamore.
4. Liriodendron tulipifera, L. Tulip tree, (or wrongly, yellow poplar.)
5. Dirca palustris, L. Leatherwood.
6. Nyssa multiflora, Wang. Sour gum.
7. Sassafras officinalis, Nees. Sassafras.
8. Lindera benzoin, Meisn. Spice bush.
9. Cornus alternifolia, L. Alternate-leaved cornel.
10. Rhus glabra, L. Smooth sumach.
11. Rhus toxicodendron, L. Poison ivy.
12. Rhus aromatica, Ait. Fragrant sumach.
13. Zanthoxylon americanum, Mill. Prickly ash.
14. Ptelea trifoliata, L. Hop tree.
15. Robinia pseudacacia, L. Locust
16. Gleditschia triacanthos, L. Honey locust.
17. Ribes rotundifolium, Michx. Wild goosebe.ry.
18. Ribes floridum, L. Black currant.
19. Crataegus tomentosa, L. Black thorn.
20. Prunus americana, Marsh. Plum.
21. Prunus serotina, Ehrh. Black cherry.
22. Pyrus coronaria, L. Crab apple.
23. Amelanchier canadensis, Torr. & Gr. June berry.
24. Salix discolor, Muhl. Glaucous willow.
25. Betula nigra, L. Red birch.
26. Diospyros virginiana, L. Persimmon.
27. Ilex verticillata, Gr. Black alder.

PLATE IV.

1. Asimina triloba, Dun. Paw-paw.
2. Tilia americana, L. Linden.
3. Morus rubra, L. Mulberry.
4. Ulmus fulva, Michx. Slippery elm.
5. Ulmus americana, L. White elm.
6. Ulmus alata, Michx. Winged elm.
7. Celtis occidentalis, L. Hackberry.
8. Cercis canadensis, L. Red bud.
9. Hamamelis virginica, L. Witch hazel.
10. Celastrus scandens, L. Wax-work.
11. Ampelopsis quinquefolia, Michx. Virginia creeper.
12. Vitis riparia, Michx. Grape vine.
13. Smilax hispida, Muhl. Greenbrier.
14. Horizontal cut of the bud of Ulmus.

15. Horizontal cut of the bud of Celtis.
16. Horizontal cut of the bud of Populus.
17. Horizontal cut of the bud of Crataegus.
18. Horizontal cut of the leaf of Carya alba.
19. Diagram of the phyllotaxis of Quercus.
20. Diagram of the phyllotaxis of Juglans.
21. Diagram of the phyllotaxis of Ptelea.
22. Diagram of the phyllotaxis of Amorpha.

NOTE.—In these drawings the chief characteristics of these species are exposed, but it must not be expected that every specimen compared with the figure must exactly agree; there is much variation in the form of the leaf-scars within certain limits in the form of the buds, in the pubescence, etc. Not every twig of the hazel is so glandular hairy as the figure shows, not in every twig of the blue ash or burning bush, do we find the wings as in our figures, these are often only faint lines.

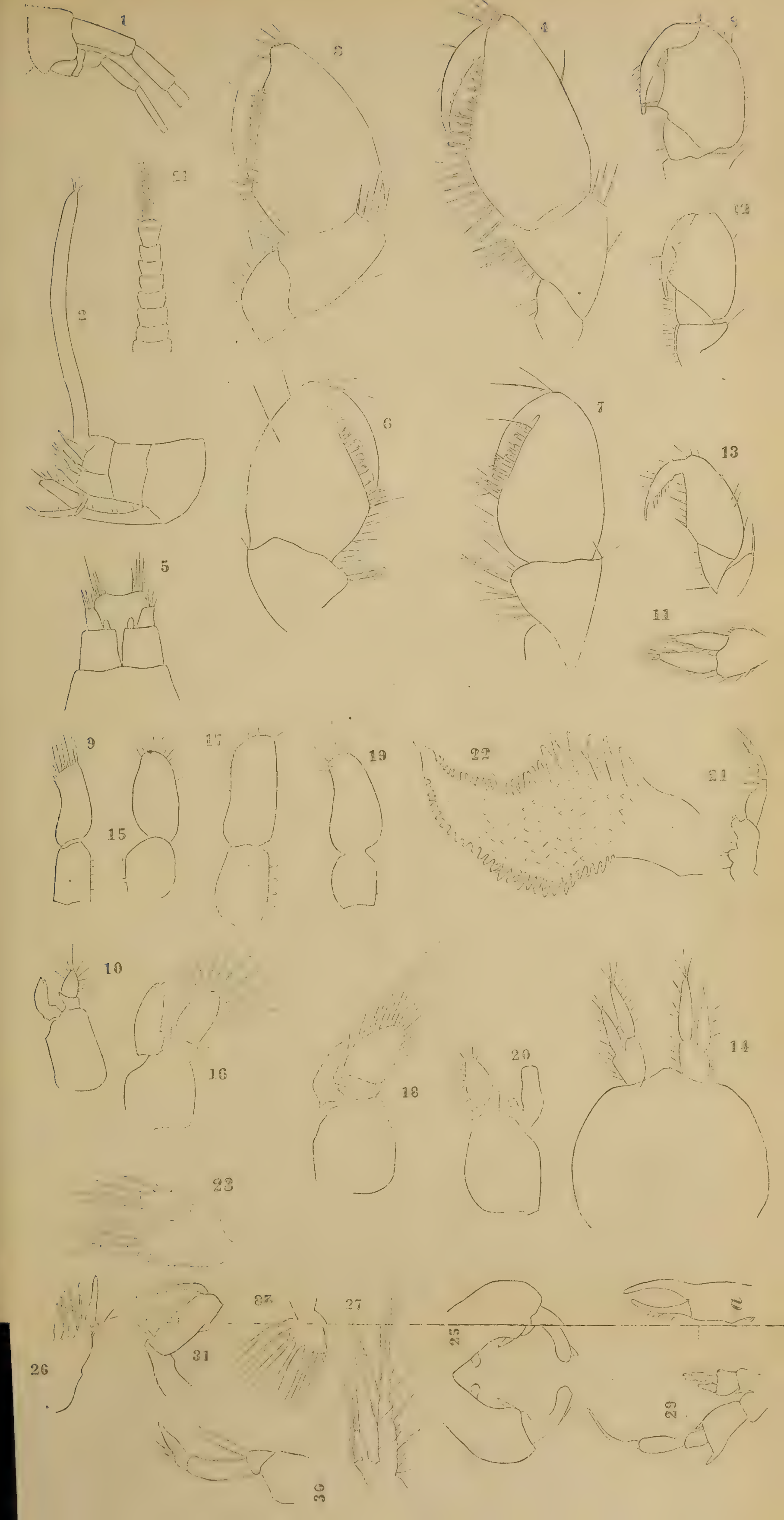
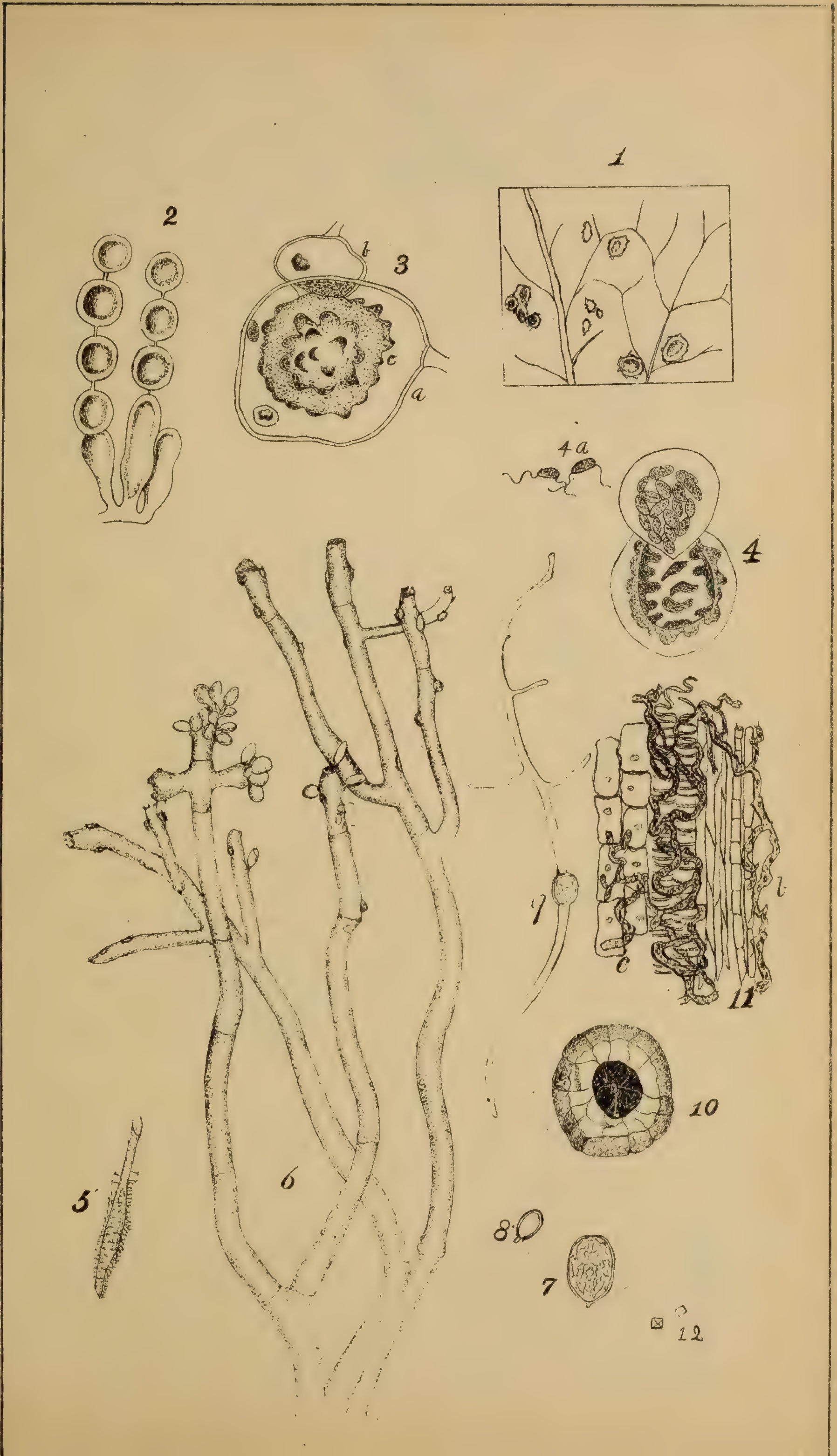
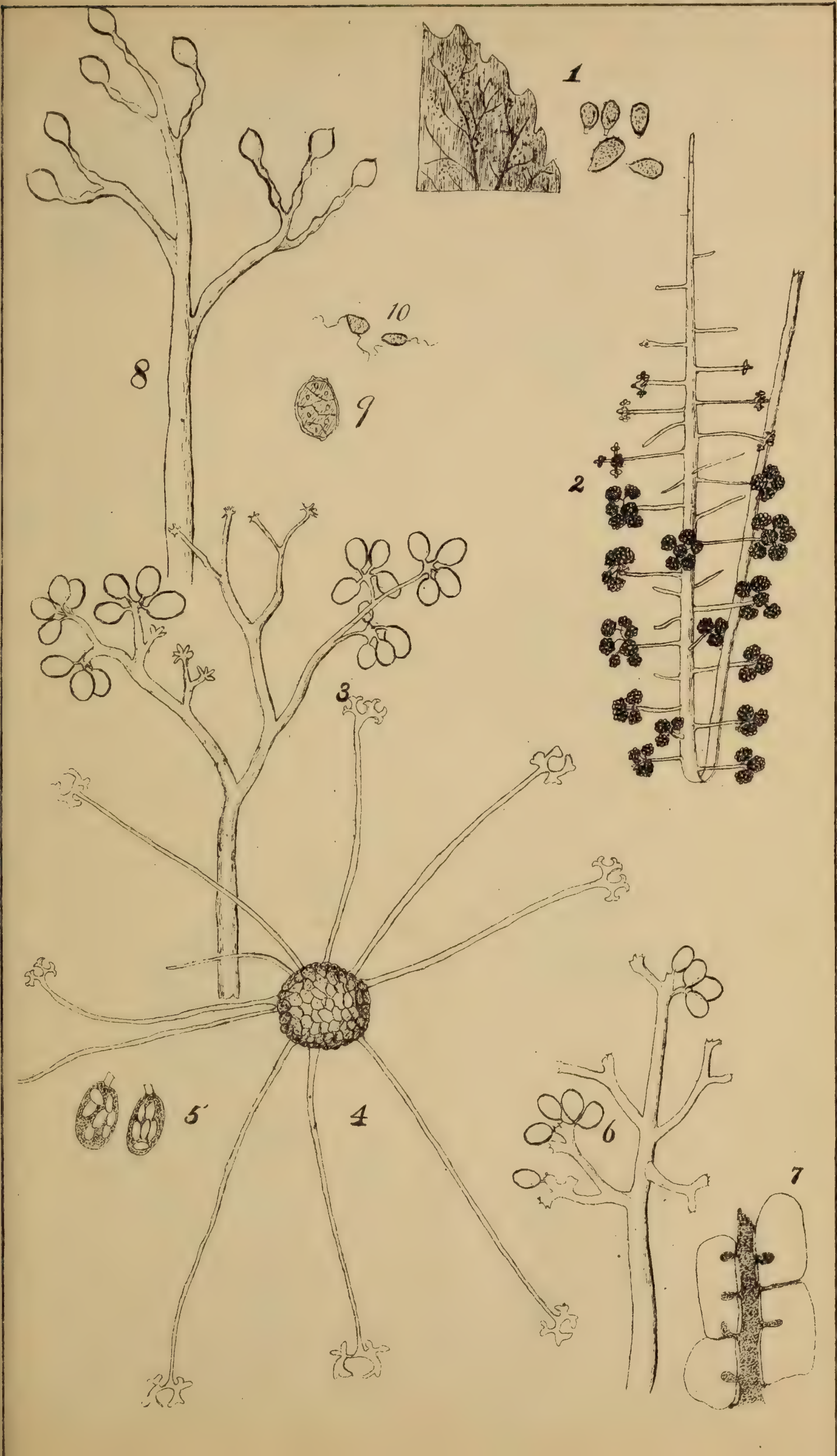


PLATE I

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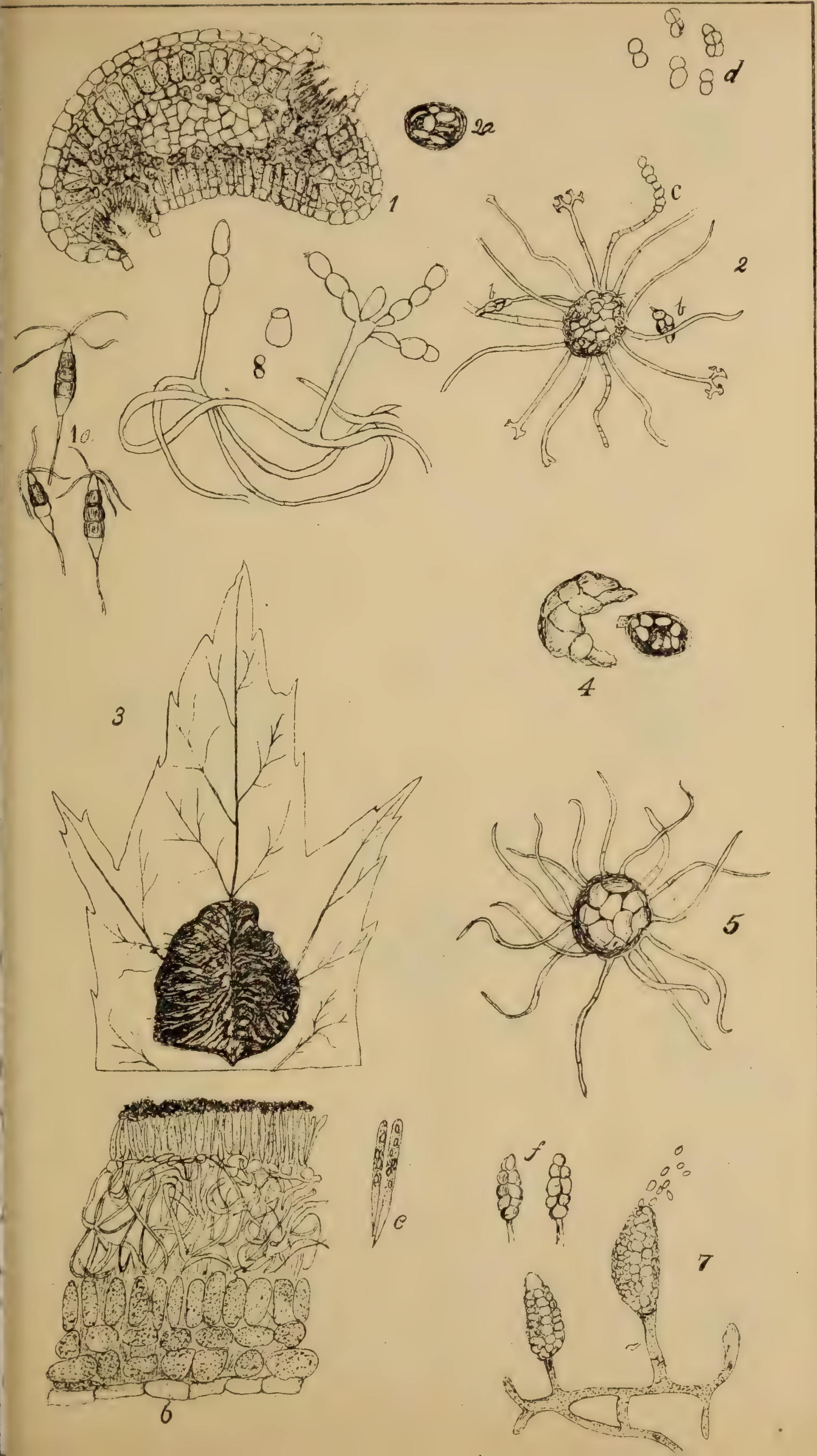
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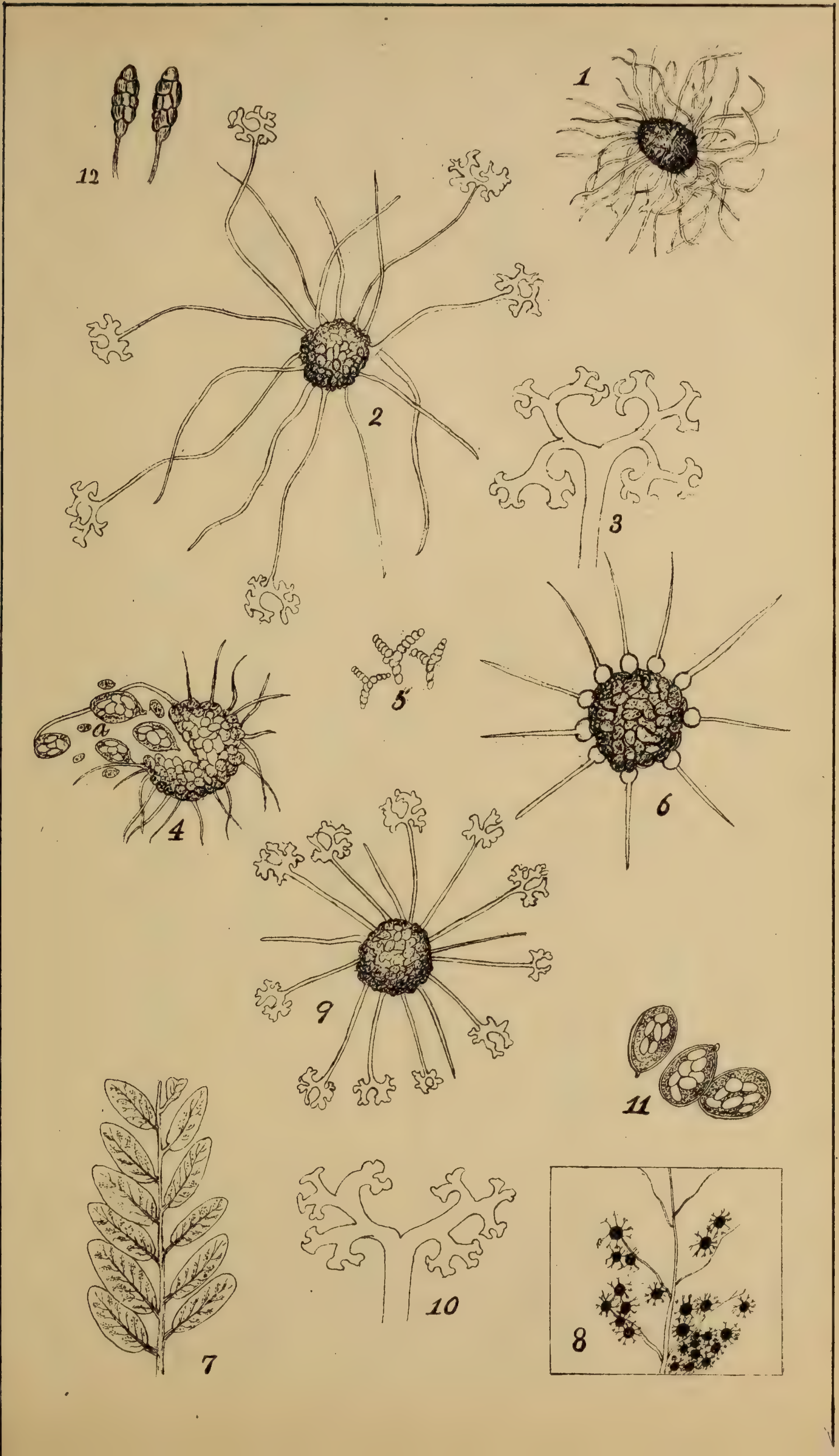
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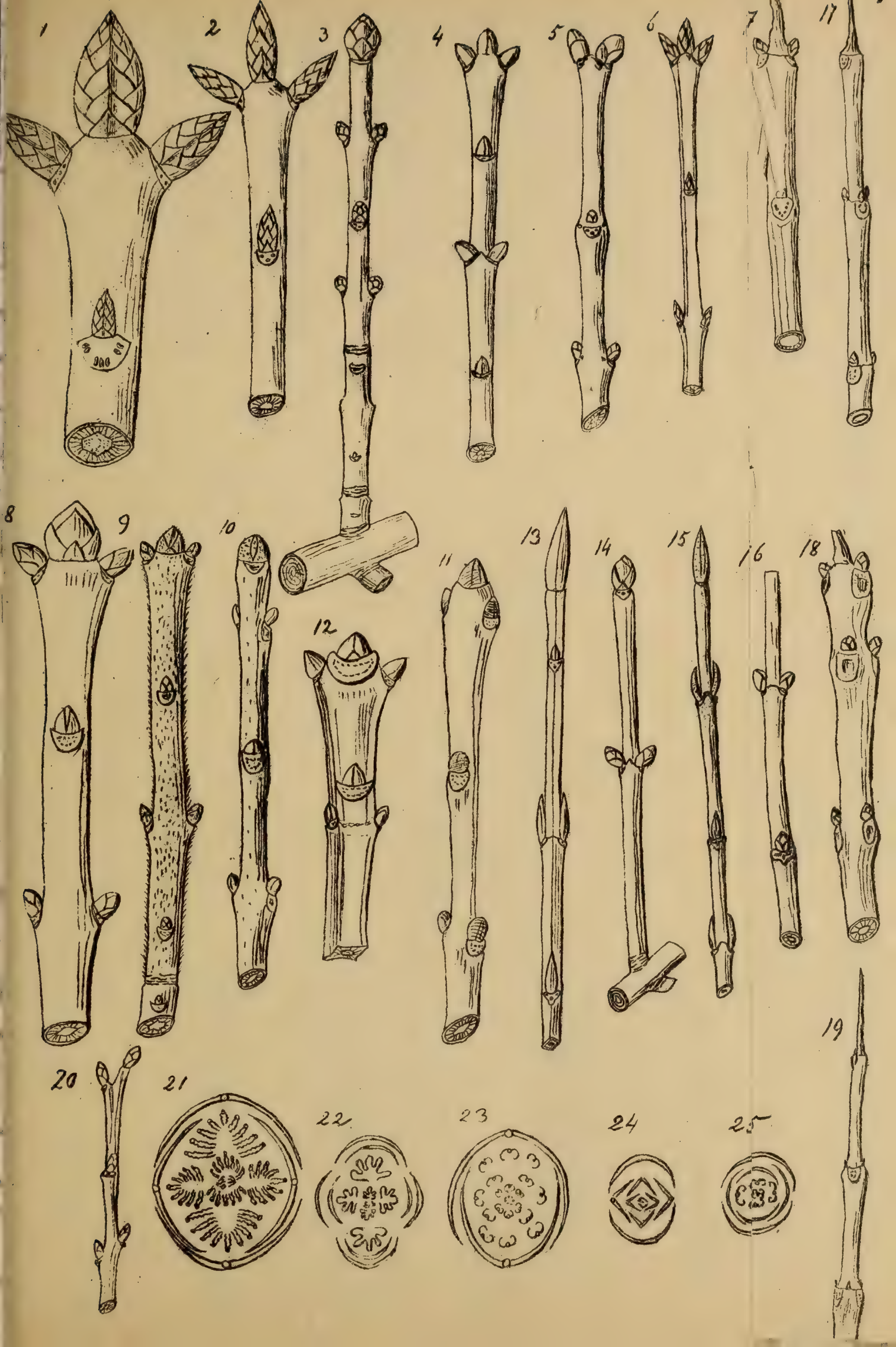
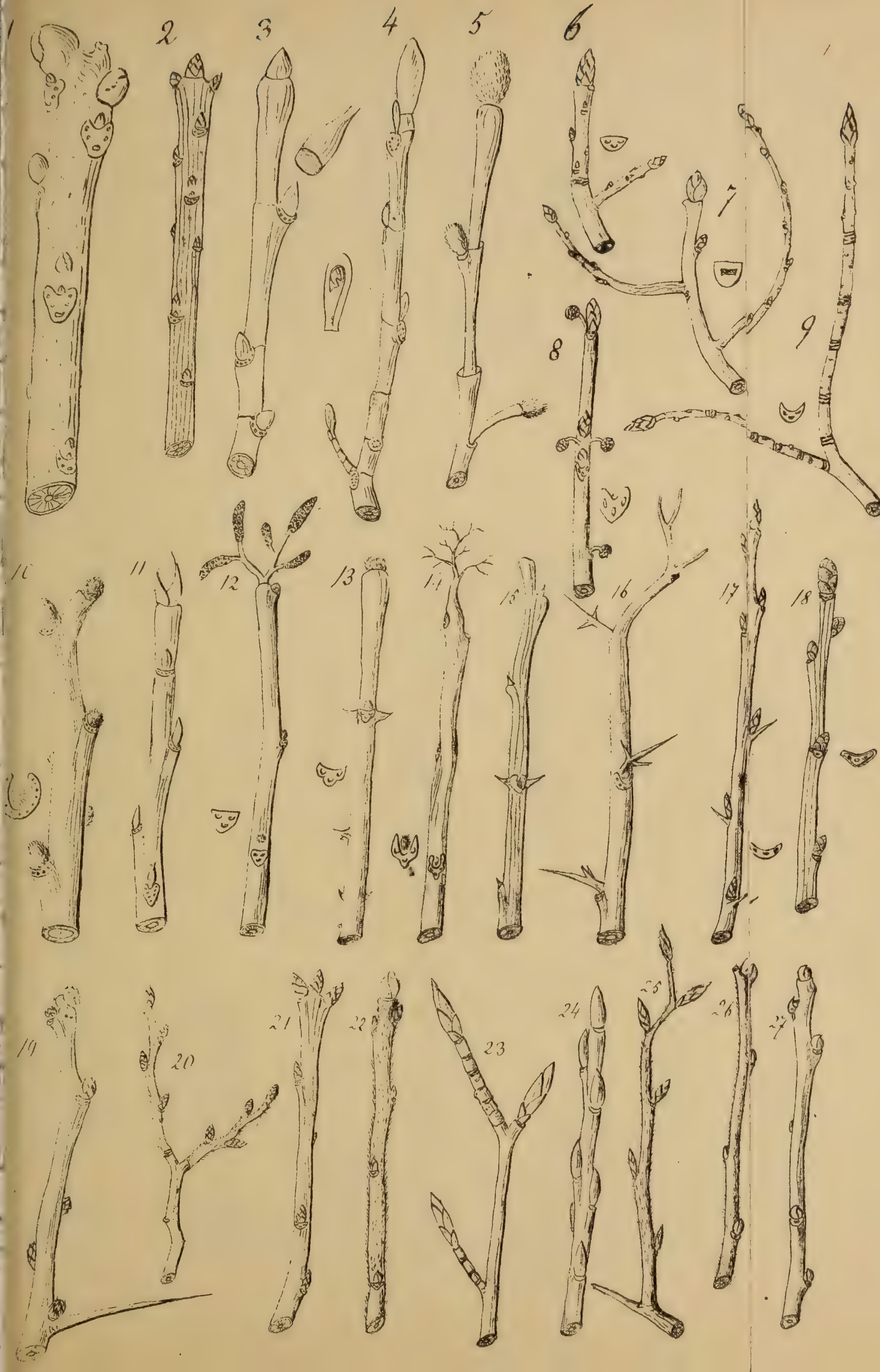


II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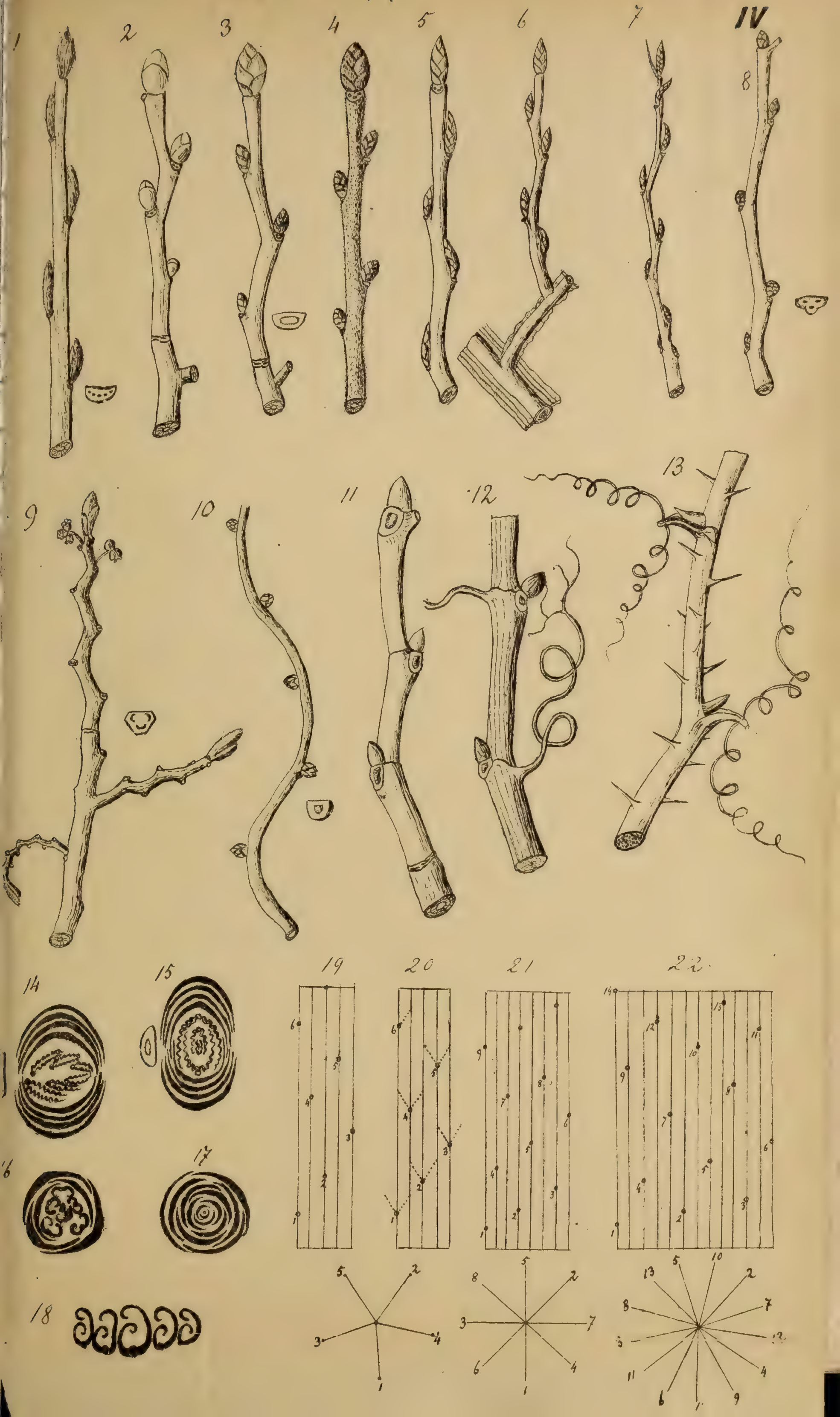
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ERRATA.

Page 33, line 5, after Report, read 1853 and '4.

Page 34, insert *Genus Poecilichthys, Ag.* between numbers 1 and 2.

Page 38, second line, for 2 1-6 read $2\frac{1}{6}$. Wherever, in this paper, two figures are separated by a hyphen, they should be written in the form of a common fraction.

Page 40, line 11, for *Aphredodereus* read *Aphredoderus;* under No. 40, for *gruuniens* read *grunniens.*

Page 44, No. 71, for *chrysochrous* read *chrysochloris;* for J. N. read J. W.

Page 45, No. 74, for E. L. read F. L.

Page 47, after 103 insert the following:—$103\frac{1}{2}$. *C. analostoma, Grd.*, Silver-fin. Every where abundant through central Illinois. Occurs less commonly further north.

Page 52, Note 2, for der read den; for Archiev. read Archiv.
Note 3, for des read der; for Wein read Wien.

Page 53, 8th line, for M. Bary read De Bary.
Note 7, for der (Brandpilze) read die.

Page 54, for *Peronosporiæ* read *Peronosporeæ.*

Page 55, 8th line, for *hauptoria* read *haustoria.*
14th line, insert (12) after six, and add one to each of the three reference numerals following.
5th line from bottom, omit (15).
2d line from bottom, insert (16) after Common.

Page 56, 10th line, 2d paragraph, in stead of '75–6 read '74–5.
15th line from bottom, for pappillate read papillate.
11th line from bottom, for *Poltactis* read *Polyactis.*

Page 57, 7th line, for *Peronosporiœ* read *Peronosporeæ.*
21st line from bottom, insert European before vine.

Page 58, 8th line, for *Peronosporiæ* read *Peronosporeæ.*
2d line, 2d paragraph, for 3 read 5.
7th and 8th lines, 2d paragraph, for one to three read twelve to fifteen.
4th line from bottom, for *bignouioides* read *bignonioides.*

Page 68, No. 40, reduce Acridium differentiale, etc., to a synonym, and insert above it C. differentialis, Thos.

Page 72, Plate II, fig. 1, for *Melanispora* read *Melamspora.*

Page 73, Plate III, fig. 3, for 3 read 5.
Plate III, fig. 5, for 5 read 3.
Plate III, fig. 7, for Plycinidia read Pycnidia.
Plate IV, fig. 12, for *fresii* read *friesii.*

INTRODUCTION.

This is the second of a series of publications, issued by authority of the State Board of Education of Illinois, and designed especially to elucidate the natural history of this State. The first number was published in December, 1876, as Bulletin No. 1 of the Illinois Museum of Natural History; but a change in the title of the institution issuing them, necessitates a change in the title of the series.

S. A FORBES,
Director Ill. State Lab. of Nat. Hist.

NORMAL, Ill., Dec. 12, 1877.

A List of the Species of the Tribe Aphidini, family Aphidae, found in the United States, which have been heretofore named, with descriptions of some New Species.

By CYRUS THOMAS, Ph. D.

Printed Dec. 13th, 1877.

A Synoptical Table of the Sub-families of Aphidae, as given by Buckton.

I. Front wings with three discoidal veins, the third twice forked; hind wings with two discoidal veins. 1. *Aphidinae.*

II. Front wings with three discoidal veins, third with one fork; hind wings with two discoidal veins. (One in *Colopha.*) 2. *Schizoneurinae.*

III. Front wings with three discoidal veins, all simple; hind wings with one or two discoidal veins. 3. *Pemphiginae.*

IV. Front wings with the third discoidal vein wanting; sometimes never acquiring wings. 4. *Chermesinae.*

The first sub-family, Aphidinae, is further divided by Buckton into two tribes as follows:

I. Antennae seven-jointed, Tribe 1, *Aphidini.*
II. Antennae six-jointed, Tribe 2, *Lachnini.*

These characters, however, are calculated to deceive, as the sixth joint in many species of the second tribe consists of two parts, corresponding to the sixth and seventh joints in the first; in fact, the author speaks of these antennae as seven-jointed. The first of these tribes corresponds to Passerini's sub-family *Aphidinae.*

TRIBE 1. APHIDINI.

Genus SIPHONOPHORA, KOCH.

Antennae very long, on tubercles; honey tubes long, cylindrical.

1. Siphonophora acerifoliae, new sp.

Winged, viviparous female. General color light grey, varied with white and ash-brown. Antennae extending beyond the tip of the abdomen, nearly to the tips of the wings. The three ocelli distinct. Prothorax with depressed, expanded lateral margins. From the back of each of the first three or four abdominal segments, arise two distinct, slender, somewhat curved spines. Honey-tubes not extending beyond the tip of the abdomen. Most of the veins of the front wings, especially the fourth and the forks of the third, expand at the tips, forming dusky spaces; the subcostal vein is strictly parallel with the costa; stigma short and rather small.

Basal joints of the antennae dull yellowish, with a narrow darker ring at the apex of the third and fourth joints; more or less of the fifth of a transparent whitish color, forming an annulus; sixth and seventh dusky.

Head pale brownish, with a narrow white median line; eyes red; prothorax same color as the head, with more or less distinct, very narrow, abbreviated, longitudinal white lines; abdomen marked with a few white dots somewhat regularly arranged, powdered with white behind the honey-tubes. The white lines and spots appear to be formed by a very fine white powdery substance. The spines on the abdomen black. Honey-tubes brown, white at the immediate tips.

Apterous individuals, (probably not fully grown.) Pale pea-green; eyes dark; apical portion of the antennae dusky; tibiae dusky at the base; honey-tubes pale green. The surface of the body smooth and shining.

Found on leaves of *Acer dasycarpum*, chiefly on the under side, somewhat sporadic and not aggregated in large colonies. Winged specimens very active and apparently capable of leaping. Slightly above medium size, but less than *S. rudbeckiae.*

It is possible that this Aphis should be placed in *Drepanosiphum*, or a new genus be formed for its reception.

2. Siphonophora rudbeckiae, FITCH. Senate 30, 66, 1851.

On *Rudbeckia laciniata*, *Ambrosia trifida*, and *Solidago serotina.*

3. Siphonophora ambrosiae, new sp.

Similar in size and appearance to *S. rudbeckiae*, but varying in color from a light brown to a dark seal brown.

Winged individuals. Discoidal veins of the front wings strongly curved. Antennae passing the tip of the abdomen, light brown, dark at the apex. Honey-tubes long, cylindrical, reaching beyond the tip

of the abdomen. Tail long and pointed. Body not tuberculate; antennae with alternate hairs, which, under a high power, appear to be capitate.

Apterous individuals. Body more or less covered with tubercles, out of which proceed hairs, which, in some specimens at least, are capitate. A similar characteristic has been noticed by Buckton in *Myzus ribis*, a species found on the Red Currant and the Gooseberry.

Honey-tubes dark, or the same color as the body, tail yellowish brown. Beak dark at the tip, reaching to the third coxae.

Found September 1st, at Sioux City, Iowa, on the leaves and flower-stems of *Ambrosia psilostachya.*

4. Siphonophora rosae, Reaum.

Aphis rosae, Reaum. Ins., iii, Pl. 21, Fig. 1–4.
Siphonophora rosae, Koch, Pflanz., 178.

On the tender shoots, leaf-stalks and flower-stalks of various cultivated and wild roses.

5. Siphonophora avenae, Fab.

Aphis avenae, Fab., Sp. Ins., ii, 386.
" granaria, Kirby, Linn. Trans., iv, 238.
" hordei, Kyber, Germ. Mag., Leit. ii.
" cerealis, Kalt., Mon. Pflanz., I, 16, 6.

On Wheat, Oats and Barley leaves, stems and roots, according to the time of the year.

6. Siphonophora viticola, new sp.

Apterous female. Rather broadly ovate, wide behind, about .08 of an inch long. Dusky brown, somewhat paler in front. Antennae scarcely as long as the body. Honey-tubes very long, slightly curved and slightly enlarged at the base, cylindrical, and fully one-fourth the length of the body. Honey-tubes, legs and antennae black, except that there appears to be a broad pale annulus on the last near the base, and in many specimens several pale rings. Tail distinct.

Winged viviparous female. Similar to the wingless, somewhat more slender; front parts darker, the head and central parts of the thorax being dark brown.

The second discoidal vein more than usually distant from the third; stigma dusky or brown, elongate, with sides parallel, pointed at the tip.

In June and July, on the leaves near the tips of the branches, and also the tender twigs of cultivated grape vines.

Whether this is the *Aphis vitis* of Scopoli or not, I have no means at present of ascertaining.

7. Siphonophora setariae, new sp.

Winged viviparous female. Antennae about as long as the body or slightly longer; general color brown or brownish, usually with a slight

olive tint. Subcostal vein of the fore wings parallel with the costal; the three discoidal veins about equidistant at their bases; stigma fusiform, opaque, brown.

Apterous female. Honey-tubes extending slightly beyond the tip of the abdomen, black; tail white; legs yellow, except the joints, which are dusky; the femora are generally pale at the base. Antennae about as long as the body, marked as in the pupa, except that the light portions are clear white. Beak reaching nearly to the hind coxae.

Pupa. Oval, width about two-thirds the length; length about .05 inch. Antennae nearly as long as the body; first and second joints dusky, third and fourth bright yellow, apex dusky. Eyes black. Wing-pads greenish at the base.

Found on the heads of *Setaria glauca* and *Panicum crus-corvi*, Carbondale, Illinois, in August.

It is possible that those found on *Panicum* belong to a different species, as the wingless specimens are of a lighter color, and have a distinct tubercle on the sides of the neck, which I failed to observe in those on *Setaria*. If it should appear that these are specifically distinct, the species may be named *Siphonophora panicola*.

8. Siphonophora euphorbiae, new sp.

Notes in reference to color lost. If I remember rightly, it was green or greenish, similar in color to the following species, but distinct.

Antennae longer than the body, very slender; the third and seventh joints very long; a few regularly placed hairs on them. Honey-tubes long and slender, reaching beyond the tip of the abdomen, nearly one-third as long as the body, cylindrical. Tail very distinct, ensiform and slender, about half the length of the honey-tubes. Subcostal vein of the front wings diverging as it leaves the base, so as to leave the widest space between it and the costal vein opposite the insertion of the first discoidal vein, then approaching and joining it at the stigma.

Found at Sioux City, Iowa, September 1st, on *Euphorbia maculata*.

The specific name *euphorbiae* has already been used in *Aphis*, but this being in a different genus, it will not create confusion.

9. Siphonophora euphorbicola, new sp.

Winged viviparous female. Antennae longer than the body; general color pale pea-green; honey-tubes long, extending beyond the tip of the abdomen, equal in length to about one-fourth of the body. Head pale glaucous, the two lateral ocelli distinct; eyes dark; antennae dusky, except the basal joints and base of the third joint, which are pale. Thorax with a slight purplish tint; prothorax green; abdomen pale green; legs hyaline. Honey-tubes pale green at base, dusky at the tips; tail long, slender, sword-shaped, greenish. Veins of the wings slender and very straight, except the stigmatic, which is strongly curved. Beak reaches the hind coxae. Length to tip of abdomen .09 inch; to tips of wings .15 inch.

Apterous female. Pale green throughout, except the eyes, which are dark. Some specimens tuberculate.

Closely allied to *S cyparissiae*, Koch, but that species has red eyes.

Found at Sioux City, Iowa, about the 1st of September, on *Euphorbia marginata*, on the leaves and leaf-stalks.

10. Siphonophora asclepiadis? FITCH. Senate, No. 30, 65, 1851.

On *Asclepias cornuti*. Referred with some doubt to this species.

Dark green with dusky shadings.

11. Siphonophora erigeronensis, new sp.

Winged viviparous female. Green, the antennae, eyes and honey-tubes black. Antennae as long as the body or rather longer; honey-tubes very long, passing the abdomen, nearly equal in length to one-third the body; cylindrical, deep black. Tail distinct, rather slender, and curved upwards. Legs long and slender, black, except the basal half of each femur, which is transparent green. Head and thorax deeper green than the abdomen.

Length to tip of abdomen, .08 inch; to tips of the wings, .13 inch.

The young are pale greenish-yellow. Fully grown wingless individuals, pale pea-green.

Found in August, at Carbondale, Illinois, upon the flower-stalks of *Erigeron canadensis*.

12. Siphonophora coreopsidis, new sp.

Winged individuals. Antennae about two-thirds the length of the body; joints proportioned as usual. Honey-tubes long and cylindrical, length equal to about twice the distance to the tip of the abdomen. Head and thorax black; abdomen greenish-yellow, with a grass-green spot on the back next the thorax, and three green spots along each side, one to a segment; antennae, legs and honey-tubes black; tail the color of the abdomen. The wings present a slightly smoky appearance; costal vein, stigma and discoidal veins, very dark, almost black; subcostal with a yellowish tint

Apterous female. Head pale yellow; thorax yellowish-green; abdomen greenish-yellow, with a grass-green streak running from the thorax to the tip of the abdomen, also one running across near the thorax; the hind margin of the abdomen from the base of one honey-tube to the other is of a reddish tint. Eyes black. Wing-cases of the pupa black.

Found by Mr. Th. Pergande, in October, at St. Louis, Missouri, on *Coreopsis aristosa*, infesting the flower stalks.

13. Siphonophora lactucae, KALT., Mon. Pflanz.

On the garden lettuce.

Buckton appears to think this distinct from *Aphis lactucae*, Linn., or *S. lactucae*, Koch.

14. Siphonophora polygoni, Walk.

Aphis polygoni, Walk., Zool., vi, 2249.

On *Polygonum persicariae.*

15. Siphonophora salicicola, new sp.

I have not seen this species living, hence cannot give the colors; and I have some doubt as to its generic position, the antennal tubercles not being very distinct, and the plant on which it was found not the kind on which the species of this genus usually reside.

Winged individual. Antennae seven-jointed, of the usual form in this genus; apparently on tubercles; all the joints transversely wrinkled. Beak of medium length. Tail distinct, curved upwards, expanding in the middle, and about half the length of the honey-tubes. Honey-tubes long, reaching beyond the tip of the abdou en, cylindrical. Wings with the neuration as usual in this genus, the second fork of the third discoidal vein very near the tip, the distance to the tip not more than one-sixth the distance to the junction of the first fork with third vein.

Specimens in glycerine. Found in June, by Miss Emma A. Smith, at Peoria, Illinois, on willow.

It is evidently not the *Aphis salicicola*, Uhler, (*A. salicti*, Harr.) which is a *Lachnus.*

16. Siphonophora verbenae, new sp.

Wingless female. Of a bright pea-green color throughout, (some specimens yellowish-green ;) with two or three deeper green, longitudinal stripes on the abdomen. Eyes black. Antennae about as long as the body, pale and colorless, except at the tips, where they are dusky. Honey tubes reaching to or slightly beyond the tip of the abdomen, cylindrical, pale. Tail rather short, whitish. Body regularly ovate, somewhat elongated; medium size.

Found at Carbondale, Illinois, November, on the leaves of *Verbena.*

The following species are mentioned as probably found in the United States, introduced from Europe.

17. Siphonophora rubi, Kalt.

Shining green and slightly pilose. On the Blackberry.

18. Siphonophora pisi, Kalt.

Various shades of green. On the Pea.

19. Siphonoyhon tanaceti, Linn.

Brown, with lighter shades. On the common Tansy.

20, Siphonophora fragariae, Koch.

Green. On the Strawberry.

Genus PHORODON.

Similar to *Siphonophora* in some respects, and to *Aphis* (restricted) in others. Chief distinguishing character, the spine-like prolongation of the inner side of the antennal tubercle, and of the first joint of the antennae.

21. Phorodon humuli, SCHRANK.

Aphis humuli, Schrank, Faun. Boic., II, 110, 1199.
pruni, Mahaleb, Fonscol., Ann. Soc. Ent. Fr., X, 175.
Phorodon humuli, Passerini.
The well known and injurious Aphis of the Hop-vine ; the cause of the "Blight." Green.

Genus MYZUS.

Too closely allied to *Phorodon*, the chief difference being that the frontal tubercles are not porrected in the female, and that the first antennal joint is only gibbous.

22. Myzus cerasi, FAB.

Aphis cerasi, Fab., Syst. Ent., 734, 4.
Myzus cerasi, Pass.
Shining black. On cherry leaves.

23. Myzus ? cerasicolens, FITCH.

Aphis cerasicolens, Fitch, Senate, No. 30, 65, 1851.
Pale greenish yellow. On *Cerasus serotina.*

24. Myzus ? cerasifoliae, FITCH.

Aphis cerasifoliae, Fitch.
Black, abdomen green. On leaves of *Cerasus virginiana.*

25. Myzus persicae, SULZ.

Aphis persica, Sulz , Hist. Ins., 105, Pl. II, Fig. 4, 5.
institia, Koch, Pflanz., 58, Fig. 74, 75.
persicaecola, Boisd.
persicophila, Rondani.
Myzus persicae, Pass.
Red and brown. On the Peach and Nectarine.

26. Myzus ribis, LINN.

Aphis ribis, Linn., Syst. Nat., II, 733.
Rhopalosiphum ribis, Koch, Pflanz., 39, Fig. 50, 51.
Myzus ribis, Pass.
Green to yellow. On leaves of Red Currant.

Genus CHAITOPHORUS.

Similar to *Aphis* (restricted) in form and antennae; honey-tubes very short; legs, antennae, and usually the body, hairy (hirsute).

27. Chaitophorus negundinis, new sp.

Winged individual (in glycerine).—Wings very thin and delicate, and veins very slender; the costal vein bends outward from the base to the insertion of the second discoidal vein; the stigmatic vein starts from the stigma far back near the middle, curves slightly and gradually for a short distance and is then almost straight to the apex of the wing; stigma very long and slender; veins and stigma pale yellowish. Antennae nearly as long as the body, sparsely covered with long stiff hairs. Honey-tubes short. Apparently greenish.

Found at Peoria, Illinois, in June, by Miss Smith, on *Negundo aceroides*.

28. Chaitophorus populicola, new sp.

Winged specimens. Antennae not very long, somewhat hairy. Wings transparent, but along each discoidal vein there is a broad smoky border; stigma dark; when examined by a strong power the wings appear to be covered with scales; when examined by an ordinary pocket lens they present a very pretty appearance, as though marked by dark cross bands Head and thorax shining black; neck dull yellowish; abdomen yellowish, with some irregular dusky patches toward the tip. Antennae, which reach about the middle of the abdomen, dusky, the basal half paler; legs dark, the bases of the femora pale; beak short, reaching only to the middle coxae.

Apterous female. Reddish-brown, or tortoise-shell color; a large, yellowish, triangular or Y-shaped spot, (the forks pointing backwards) on the middle part of the abdomen; honey-tubes reduced to simple tubercles, yellow. There is often a palish stripe along the middle of the head and thorax. Antennae pale yellowish at the base. Length about .05 of an inch

Body more or less hairy; and although my notes, made at the time, fail to mention the fact, I think that some, at least, of the apterous specimens were covered with tubercles.

Found in July, at Carbondale, Illinois, and the first part of September, at Dubuque, Iowa, on the under sides of the leaves of young sprouts of *Populus angulata*.

The remaining species of the tribe are placed in the genus *Aphis*. Those which are new and those heretofore described which I have been able to examine, appear to belong to the genus as restricted; the others require further examination.

29. Aphis vernoniae, new sp.

Winged individuals.—Rather small, .06 to .08 of an inch in length to the tip of the abdomen; .12 inch to the tips of the wings. General

eral color bright lemon yellow ; thorax yellow, except the lobes, which are brown or blackish ; eyes black ; antennae pale or dusky ; abdomen yellow ; honey-tubes yellow or ochreous ; tail yellowish ; legs pale.

In some specimens the thorax is dark ; the abdomen greenish-yellow.

Antennae seven-jointed, nearly as long as the body. In some specimens (probably males) they appear to be on tubercles, which are prolonged on the interior margin ; seventh joint about as long as the fifth and sixth united. Honey-tubes slender, cylindrical, and reaching about to the tip of the abdomen. Tail short and blunt. In some (wingless) specimens there is a distinct tubercle on each side of the prothorax, and another on each side just above the posterior coxae, but these were not observed on the winged individuals.

Wingless individuals.—Color almost uniform greenish-yellow ; eyes black ; honey-tubes yellowish ; tail whitish ; legs pale.

Found in June, at Carbondale, Illinois, on the under side of the leaves and stems of *Vernonia fasciculata* ; also about the first of September, at Ft. Dodge, Iowa, on the flower stalks of the same plant. The latter presented some slight differences from the former. Is closely allied to *A. beccabungae*, Koch, and possibly identical with it.

30. Aphis mali, Fabr., Syst. Ent., 737.

Aphis pyri, Reaum., Ins., III, 281,350.

On the leaves and tender twigs of the Apple.

31. Aphis malifoliae, Fitch, Fourth Rep. N. Y. S. Cab., 49.

Probably a variety of the preceding. On apple leaves.

32. Aphis cephalanthi, new sp.

Wingless female.—Of a nearly uniform purplish color, the young quite pale, the older and mature individuals darker, but more or less translucent, with a slightly pruinose cast or covering ; head and tip of the abdomen dusky ; a slightly impressed line along each side of the abdomen near the margin. Honey-tubes cylindrical, reaching about to the tip of the abdomen ; tail distinct. Beak reaches rather beyond the middle coxae. Length about .05 inch.

They give a reddish or dull orange color when crushed.

Winged individual.—Head and thorax black, abdomen pale purplish, marked along the margin with pruinose spots. Two pruinose spots on the abdomen immediately behind the thorax ; tip of the abdomen dusky ; about four of the pruinose spots on each side anterior to the honey-tubes and two behind them. Antennae very slender, dusky, reaching about to the middle of the abdomen. Legs pale, except the joints and tarsi, which are dusky. Wings transparent, but with a slightly smoky shade when seen erect in the living insect ; veins dark, except the subcostal or midrib, which is pale.

Length to tip of abdomen about .05 ; to tip of the wings about .12 inch.

Found in July, at Carbondale, Illinois, on the new growth of the twigs or stems of young plants of *Cephalanthus occidentalis* ; occasionally on the midrib of the leaf near the base.

It is possible that this should be placed in *Callipterus*, but the honey-tubes are rather long, and the antennae do not agree with characters as given by Koch, which, in fact, appear to be contradictory.

33. Aphis viburni ? Fabr., Syst. Ent., 737, 18.

On the tender twigs of *Viburnum opulus*.

Our species appears to be identical with the European.

General color lilac-brown ; antennae shorter than the body ; the honey-tubes short ; legs usually pale honey yellow. Illinois, June.

34. Aphis maidis, Fitch.

On the tassel, ear-stalks and roots of Indian corn. Green throughout in apterous individuals ; winged with head and thorax shining black.

35. Aphis brassicae, Linn., Syst. Nat., II, 734.

Aphis floris-rapae, Curt., Journ. Roy. Agr. Soc., III, 55.

Pale greenish-yellow. On Cabbage.

36. Aphis impatientis, new sp.

Winged individual.—Antennae extending about to the base of the honey-tubes, pale and dusky alternately ; head black ; prothorax pale brown, rest of the thorax shining black ; abdomen pale brownish ; honey-tubes not reaching the tip of the abdomen, black ; tail dull yellowish ; veins of the wings and stigma brown ; wings iridescent ; legs dusky, tibiae pale yellow. Length to tip of abdomen about .10 inch, to tip of wings .18 inch.

Apterous specimens.—Olive or purplish-brown.

Found in August, at Carbondale, Illinois, on *Impatiens fulva*.

Is an Aphis in the restricted sense.

37. Aphis symphoricarpi, new sp.

Apterous individuals—(No winged specimens observed).

There appear to be two varieties, but evidently belonging to the same colonies.

One is pale, transparent green or yellowish green ; eyes black ; antennae pale, with a black ring a little beyond the middle, tips dusky ; honey-tubes and a small space around the base ochre yellow ; tarsi and tip of the beak black ; legs pale, transparent greenish. Bodies rather

broadly ovoid, and very convex; abdomen very distinctly acuminate at the apex, but no tail apparent.

The other variety is rather less convex, and the dorsal surface is more or less shaded with brown; in the darker specimens this color sometimes occupies most of the back; there is usually a median line or stripe of green on the posterior half of the abdomen, which can often be indistinctly traced to the thorax; the thorax generally more or less shaded with pale brown; tip of the abdomen usually pale or greenish, and not acuminate as in the other variety; tail distinct but short, whitish; honey-tubes dark at the tips; remainder, and a space around the base, yellowish-brown.

Legs rather short. Antennae reaching to the honey-tubes or nearly to the tip of the abdomen; honey-tubes very short, almost reduced to tubercles, length about twice their diameter.

Found at Ft. Dodge, Iowa, about the first of September, on the leaves of *Symphoricarpus vulgaris*; on the under side of the leaves near the ends of the branches.

38. Aphis pruni, KOCH, Pflanz., 68, Figs. 88-90.

Aphis prunifoliae, Fitch.

Green, with more or less black. On the leaves of native and cultivated plums.

39. Aphis rumicis, LINN., Syst. Nat., II, 734.

For the numerous synonyms given by Walker, See Walker, List, Homop. Brit. Mus., 981. Also Trans., Ill. St. Hort. Soc., 1876, 163. Some of these synonyms are erroneous.

Black. On the Bean, Dock, &c.

40. Aphis cornifoliae, FITCH. Senate, No. 30, 65, 1851.

Black. On the leaves of *Cornus paniculata.*

41. Aphis circaezandis, FITCH.

Head and thorax black. On leaves of *Galium circaezans.*

42. Aphis crataegifoliae, FITCH. Senate, No. 30, 66, 1851.

Black, abdomen green. On the leaves of *Crataegus punctata.*

43. Aphis betulaecolens, FITCH. Ibid.

Sulphur-yellow. On the Beech. Probably belongs to *Callipterus.*

44. Aphis sambucifoliae, FITCH. Ibid.

Black (probably greenish-black? . On Elder leaves. It is quite probable this is *A. sambuci*, Linn.

45. Aphis pinicolens, Fitch. Ibid.

Straw-yellow. On the Pine.

46. Aphis populifoliae, Fitch. Ibid.

Chestnut-brown, pruinose. On leaves of *Populus grandidentata*. Probably belongs to *Chaitophorus*, and may be identical with the one one I have named *Ch. populicola*; but Dr. Fitch's description is too short and unsatisfactory to decide this point.

47. Aphis candicans, Fitch.

On the leaves of *Populus candicans*. Probably belongs to *Chaitophorus*.

48. Aphis gossypii, —–? Pat. Off. Rep., 1855.

Green or yellow, thorax striped with black. On the leaves of cotton.

49. Aphis ? caryella, Fitch.

50. punctatella, Fitch.

51. maculella, Fitch.

52. fumi pennella, Fitch.

53. marginella, Fitch.

These species, according to Dr. Fitch, are found on the Hickory. It is more than probable that they are varieties of one species. They most likely belong to Passerini's genus *Pterocallis*; at any rate they belong to the tribe under consideration.

54. Aphis aceris, Linn., Syst. Nat., II, 736.

Occurs, according to Dr. Fitch, on *Acer pennsylvanicum*. If he is correct in his determination, it will belong to the genus *Chaitophorus*. The winged specimens black, the apterous yellowish and very hairy; honey-tubes very short.

Genus Rhopalosiphum.

Similar to *Siphonophora*, but differs in having the honey-tubes enlarged in the middle.

55. Rhopalosiphum berberidis ? Kalt., Mon. Pflanz., 95.

Aphis berberidis, Fitch, Senate, No. 30, 65, 1851.

Black, abdomen yellow. On the leaves of *Berberis vulgaris*.

I doubt the identity of Fitch's and Kaltenbach's species, although infesting the same plant; the difference in color is too great.

I also give descriptions of some new species belonging to other tribes, with notes on a few species heretofore described.

Lachnus quercifoliae ? Fitch.

The following is a description of what I presume to be Dr. Fitch's *L. quercifoliae.*

Apterous individuals.—(apparently hardly full-grown).

Antennae longer than the body; third joint longest, the second about four-fifths the length of the third, thence decreasing regularly to the sixth, which is divided into two parts differing in diameter, or there is a seventh which is not more than half of the length of the sixth; sparsely covered with hairs placed alternately. Honey tubes very short, the diameter exceeding the length, snowy white; tail short, semicircular; body slightly hairy. General color brown; head paler and yellowish; first two pairs of legs transparent white; hind legs brown, except the tarsi, which are pale. Beak whitish, and reaching slightly beyond the third coxae. The young are yellowish white, with pale-brown patches; as they increase in age, they grow darker, assuming a tortoise-shell appearance; the middle of the back and a spot each side of the abdomen at the shoulders pale. The older specimens show a distinct ridge along each side of the abdomen. Segments of the abdomen very distinctly marked. Nearly oval in form; length less than one-tenth of an inch. Tibiae hairy.

Found on the upper surface of the leaves of the White Oak, at Carbondale, Illinois, in August.

I have some doubt in reference to the position assigned this species by Dr. Fitch, if indeed it be his species.

Rhizobius eleusinis, new sp.

The body very broadly ovate and very convex, almost globular; the abdomen abruptly rounded behind, the last segment small and conical, appearing in the older or completely grown specimens as a short tail; tapering regularly from the middle of the abdomen forward to the head, the thorax and thoracic segments distinguished only by the deeper sutures and position. Eyes very minute, almost obsolete. Antennae very short, not reaching beyond the thorax, six-jointed, first and second thickest, rest cylindrical, of equal thickness; third longest, sixth next, fourth and fifth equal in length; slightly hairy (under strong magnifier) especially the sixth joint. Beak reaching fully to the hind coxae. General and almost entire color a milky white; apical half of the antennae and tip of the beak dusky or black; the older specimens have two or three transverse fuscous bands on the thorax and posterior part of the abdomen. The under side often presents, on the lateral margins, abbreviated, transverse, brownish stripes, but the middle part is smooth and white. The legs are dirty white, more or less touched with pale brown.

Length about .05 to .07 of an inch. The species of this genus, as far as known, never acquire wings.

Found during September, at Carbondale, Illinois, on the roots of *Eleusine indica.*

Tychea panici, new sp.*

Antennae very short, in the specimens examined, which appear to be scarcely fully grown; not reaching beyond the prothorax, apparently five-jointed; joints nearly equal to each other, sub-moniliform. Body ovate, very convex. Apparently without eyes, at least I failed to find them with a pretty high power, yet Mr. Pergande appears to have found specimens in which they were minutely represented, as shown in the figure drawn by him. Beak very short, reaching but little beyond the first coxae. Legs unusually short, the hind pair being scarcely longer than the others. Without honey-tubes or anything representing them. Divisions between the segments not well marked Uniform orange red or reddish-yellow; beak tipped with fuscous. Length not more than about .04 of an inch.

Found during October, by Mr. Th. Pergande, at St. Louis, Mo., on the roots of *Panicum glabrum.*

This is probably a species of *Tychea*, which has, according to Koch, six-jointed antennae, but according to Passerini, only five.

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*The winged form of this species has probably been discovered by Mr. Pergande since the above description was printed. It apparently belongs to the genus *Schizoneura.*

A NEW SPECIES OF APHIS, OF THE GENUS COLOPHA.

By MISS NETTIE MIDDLETON, ASST. ST. ENT., ILL.

Printed March 20th, 1878.

Colopha eragrostidis, new sp.

Winged individual.—General color reddish-brown; head black; prothorax yellowish, rest of the thorax and abdomen reddish brown; veins of the wings dark; stigma pale brown.

Wings, when first seen horizontal, but becoming erect, formed and veined as usual; the third vein in the anterior pair with only one fork and obsolete nearly half way to the base of the fork; the first and second veins approximate very closely at the base. Posterior pair with but one discoidal vein.

Antennae six jointed, with the sutures between the third and fourth and between fifth and sixth transparent; first and second joints short; third about equal to the fourth, fifth and sixth united; the fourth and fifth nearly equal in length; sixth very short, but little exceeding the first and second united. The antennae as compared with the body are very short, scarcely reaching to the base of the front wings; not tapering.

Wingless individual.—Body covered with a cottony substance; beak short, not extending to the base of the second pair of legs. No honey-tubes. Length of the body .06 of an inch; to tip of wings .10 of an inch.

This species was found September 1st, 1877, on the upper leaves and fruit stems of a species of grass (*Eragrostis poaeoides* var. *megastachya*), the blades of the grass folding over the insects.

It is also found on some species of *Panicum*.

This evidently belongs to Mr. J. Monell's new genus *Colopha*, as the third vein of the front wing is but once forked, the hind wings have but one discoidal vein, and the antennae are six-jointed.

A LIST OF THE MOSSES, LIVERWORTS AND LICHENS OF ILLINOIS.

By JOHN WOLF and ELIHU HALL.

The specimens upon which the following list is based were nearly all collected by the writers; those from Menard county by Mr. Hall, those from Fulton county by Mr. Wolf. Those from Southern Illinois were mostly obtained by Mr. Wolf, as botanical collector of a party from the State Laboratory which visited the counties of Union, Johnson and Jackson, during July and August, 1877.

We are under great obligation to Prof. Leo Lesquereux, Thomas P. James, Esq., Coe F. Austin, Esq., and Henry Willey, Esq., for the determination of species, and for many other favors.

MUSCI.

ARCHIDIUM, *Brid.*

A. ohioense, *Schimp.*, Menard.

EPHEMERUM, *Hampe.*

E. crassinervium, *Schwægr.*, Fulton, Menard,

ACAULON, *Mull.*

A. triquetrum, *Spruce.*, Menard.
A. muticum, *Schreb.*, Fulton.
A. schimperianum, *Sull.*, Menard.
A. wolfii, *James*, Fulton.

PHASCUM, *L.*

P. cuspidatum, *Schreb.*, Fulton, Menard.

PLEURIDIUM, *Brid.*

P. alternifolium, *Brid.*, Fulton, Menard.

ASTOMUM, *Hampe.*

A. crispum, *Hedw.*,	Fulton.
A. sullivanti, *Schimp.*,	Menard.
A. nitidulum, *Schimp.*,	Fulton, Menard.

BRUCHIA, *Schwægr.*

B. flexuosa, *Schwægr*,	Fulton.
B. beyrichiana, *Hampe.*,	Ill.

WEISIA, *Hedw.*

W. viridula, *Brid.*,	Fulton, Menard.
W. mucronata, *Br. & Schf.*,	Fulton.

CAMPYLOPUS, *Brid.*

C. leanus, *Sulliv.*,	Fulton, Menard.

TREMATODON, *Rich.*

T. longicollis, *Rich.*,	Union, Johnson.

DICRANUM, *Hedw.*

D. varium, *Hedw.*,	Fulton, Menard.
D. rufescens, *Turner*,	" "
D. heteromallum, *Hedw.*,	" "
D. flagellare, *Hedw.*,	Fulton, Menard, Johnson.
D. scoparium, *L.*,	Fulton, Menard.
D. palustre, *Brid.*,	Ill.
D. undulatum, *Turner*,	Menard.
D. spurium, *Hedw.*, var. condensatum,	Menard.

CERATODON, *Brid.*

C. purpureus, *Brid.*,	Fulton, Menard, Lee.

LEUCOBRYUM, *Hampe.*

L. glaucum, *Hampe*,	Fulton, Menard.
L. minus, *Hampe*,	Johnson.

FISSIDENS, *Hedw.*

F. obtusifolius, *Wils.*,	Fulton.
F. minutulus, *Sulliv.*,	Fulton, Menard.
F. bryoides, *Hedw.*,	Fulton, Menard, McHenry.
F. subbasilaris, *Hedw.*,	Fulton, Menard.
F. taxifolius, *Hedw.*,	" "
F. adiantoides, *Hedw.*,	Fulton, Kane, Menard.

CONOMITRIUM, *Montagne.*

C. julianum, *Mont.*,	Fulton, Menard.
C. hallianum, *Sulliv. & Lesqx.*,	Menard.

Trichostomum, *Br. & Sch.*

T. tortile, *Schrad.*,	Fulton, Menard.
T. pallidum, *Hedw.*,	Fulton, Menard, Union, Johnson.
T. tophaceum, *Brid.*,	Ill.
T. rigidulum, *Smith*,	Ill.

Barbula, *Hedw.*

B. unguiculata, *Hedw.*,	Menard.
B. caespitosa, *Schwægr*,	Fulton, Menard, S. Ill.
B. papillosa, *Wils.*,	Menard.
B. rigida, *Schultz*,	"
B. fallax, *Hedw.*,	Fulton.
B. vinealis, *Brid.*,	Menard.
B. subulata, *Brid.*,	Ill.

Desmatodon, *Brid.*

D. flavicans, *Br. & Schimp.*	Peoria Co.

Didymodon, *Br. & Sch.*

D. rubellus, *Br. & Sch.*,	Fulton.

Pottia, *Ehrh.*

P. subsessilis, *Br. & Sch.*,	Menard.
P. exigua, *Aust.*,	"

Tetraphis, *Hedw.*

T. pellucida, *Hedw.*,	Menard.

Encalypta, *Schreber.*

E. ciliata, *Hedw.*,	Ogle.

Drummondia, *Hook.*

D. clavellata, *Hook*,	Fulton, Menard.

Orthotrichum, *Hedw.*

O. strangulatum, *Beauv.*,	Fulton, Menard.
O. canadense, *Br. & Sch.*,	Fulton.
O. crispulum, *Hornsch*,	Fulton, Menard.

Ptychomitrium, *Br. & Sch.*

P. drummondi, *Hook. & Wils.*,	S. Ill.

Grimmia, *Ehrh.*

G. apocarpum, *Br. & Sch.*,	Menard.
G. confertum, *Br. & Sch.*,	Fulton, Menard.
G. ovata, *V. & M.*,	S. Ill.

HEDWIGIA, *Ehrh.*

H. ciliata, *Ehrh.*,	Fulton, Menard.

ATRICHIUM, *Beauv.*

A. undulatum, *Beauv.*,	Fulton, Menard.
A. angustatum, *Beauv.*,	Fulton, Menard, Johnson.

POGONATUM, *Beauv.*

P. brevicaule, *Brid.*,	Fulton, Menard.

POLYTRICHUM, *Brid.*

P. commune, *Linn.*,	Fulton, Menard.
P. formosum, *Hedw.*,	Menard, Union.
P. juniperinum, *Hedw.*,	Fulton, Menard.

TIMMIA, *Hedw.*

T. megapolitana, *Hedw.*,	Fulton, Menard.

AULACOMNION, *Schwægr.*

A. heterostichum, *Br. & Sch.*,	Fulton, Menard.

BRYUM, *Br. & Sch.*

B. pyriforme, *Hedw.*,	Fulton, Menard.
B. nutans, *Schreb.*,	" "
B. roseum, *Schreb.*,	Fulton, Kane, Menard.
B. albicans, *Wahl*,	Fulton, Menard.
B. argenteum, *Linn.*,	" "
B. cernuum, *Hedw.*,	" "
B. bimum, *Schreb.*,	" "
B. intermedium, *Brid.*,	" "
B. caespiticium, *L.*,	" "
B. atropurureum, *Web. & Mohr.*,	" "
B. obconicum, *Hsch.*,	Menard.
B. uliginosum, *Br. & Sch.*,	Fulton

MNIUM, *Br. & Sch.*

M. affine, *Bland*,	Fulton, Menard.
M. punctatum, *Hedw.*,	Menard.
M. serratum, *Brid.*,	"
M. stellare, *Hedw.*,	"
M. cuspidatum, *Hedw.*,	Fulton, Menard.

BARTRAMIA, *Hedw.*

B. pomiformis, *Hedw.*,	Fulton, Menard.
B. fontana, *Brid.*,	Menard.
B. marchica, *Brid.*,	Fulton.
B. radicalis, *Beauv.*,	Menard.

FUNARIA, *Schreb.*

F. hygrometrica, *Hedw.*,	Fulton, Menard, N. Ill.
F. flavicans, *Michx.*,	Menard.
F. microstoma, *Br. & Sch.*,	"

DISCELIUM, *Brid.*

D. nudum, *Brid.*,	Fulton.

PHYSCOMITRIUM, *Brid.*

P. pyriforme, *Br. & Sch.*,	Fulton, Menard.
P. immersum, *Sull.*,	Ill.

APHANORRHEGMA, *Sulliv.*

A. serratum, *Sulliv.*,	Fulton, Menard.

FONTINALIS, *Dill.*

F. biformis, *Sulliv.*,	Fulton.
F. filiformis, *S. & L.*,	Fulton, Mason.
F. dalecarlica, *Bryol. Europ.*,	Fulton.

DICHELYMA, *Myrin.*

D. capillaceum, *Bryol. Europ.*,	Fulton.

LEUCODON, *Schwægr.*

L. julaceus, *Sulliv.*	Fulton, Menard, S. Ill.

LEPTODON, *Mohr.*

L. trichomitrion, *Web.*,	
var. immersum, *S. & L.*,	Menard, S. Ill.
L. ohioense, *Sulliv.*,	Pulaski.

ANOMODON, *Hook. & Tayl.*

A. obtusifolius, *Br. & Sch.*,	Fulton, Menard.
A. attenuatus, *Hub.*,	" "
A. tristis, *Cesati*,	" "
A. rostratus, *Hedw.*,	Fulton, Menard, S. Ill.

LESKEA, *Hedw.; Bryol. Europ.*

L. polycarpa, *Hedw.*,	Fulton, Menard, S. Ill.
L. obscura, *Hedw.*,	Fulton.
L. denticulata, *Sulliv.*,	Ill.
L. austini, *Sulliv.*,	Fulton, Menard.

CLASMATODON, *Hook. & Wils.*

C. parvulus, *Hampe*,	Fulton.

THELIA, *Sulliv.*

T. hirtella, *Hedw.*,	Menard.
T. asprella, *Schimp.*,	Fulton, Menard.
T. lescurii, *Sulliv.*,	Fulton.

FABRONIA, *Raddi.*

F. gymnostoma, *Sulliv. & Lesqx.*,	Fulton, Menard.

ANACAMPTODON, *Brid.*

A. splachnoides, *Brid.*,	Fulton, Menard, S. Ill.

PYLAISAEA, *Bryol. Europ.*

P. subdenticulata, *W. P. Sch.*,	Fulton, Menard.
P. intricata, *Bryol. Europ.*,	" "
P. polyantha, *Schreb.*,	Fulton.

HOMALOTHECIUM, *Bryol. Europ.*

H. subcapillatum, *Bryol. Europ.*,	Fulton, Menard.

PLATYGYRIUM, *Bryol. Europ.*

P. repens, *Bryol. Europ.*,	Fulton, Menard.

CYLINDROTHECIUM, *Bryol. Europ.*

C. cladorrhizans, *Bryol. Europ.*,	Fulton, Menard.
C. seductrix, *Bryol. Europ.*,	" "
C. compressum, *Bryol. Europ.*,	" "
C. brevisetum, *Bryol. Europ.*,	Menard.

CLIMACIUM, *Web. & Mohr.*

C. americanum, *Brid.*,	Fulton, Menard.

HYPNUM, *Dill.*

H. delicatulum, *Hedw.*,	Fulton, Menard.
H. minutulum, *Hedw.*,	" "
H. scitum, *Beauv.*,	" "
H. gracile, *Br. & Sch.*,	Fulton, Kane, Menard.
H. triquetrum, *L.*,	Fulton, Menard.
H. alleghaniense, *C. Mull.*,	S. Ill.
H. hians, *Hedw.*,	Fulton, Menard.
H. novaeangliae, *S. & L.*	Ill.
H. sullivanti, *Spruce*,	Fulton, Menard.
H. diversifolium, *Schimp*,	Menard.
H. strigosum, *Hoffm.*,	Marion, Menard.
H. boscii, *Schwaegr*,	Menard.
H. serrulatum, *Hedw.*,	Fulton, Menard.
H. deplanatum, *W. P. Sch.*,	" "

H. microcarpum, *C. Mull.*,	Menard.
H. micans, *Schwartz*,	
var. albulum, (*C. M.*) *Aust.*,	Fulton, Menard.
H. cylindrocarpum, *C. Mull.*,	Menard.
H. schreberi, *Willd.*,	Fulton, Menard.
H. aduncum, *Hedw.*,	" "
H. crista-castrensis, *L.*,	" "
H. imponens, *Hedw.*,	" "
H. curvifolium, *Hedw.*,	" "
H. haldanianum, *Grev.*,	" "
H. collinum, *Br. & Schf.*,	Ill.
H. salebrosum, *Hoff.*,	Fulton, Menard.
H. laetum, *Brid.*,	Fulton, Menard.
H. acutum, *Mitten*,	Menard, Fulton.
H. acuminatum, *Beauv.*,	Fulton, Menard.
H. rivulare, *Bryol. Europ.*,	" "
H. chrysophyllum, *Brid.*,	" "
H. hispidulum, *Brid.*,	Fulton, Menard, S. Ill.
H. sommerfeldtii, *Myrim*,	Fulton.
H. dimorphum, *Brid.*,	"
H. adnatum, *Hedw.*,	Fulton, Menard.
H. serpens, *Hedw.*,	" "
var. radicale, *Brid.*,	" "
var. orthocladon, *Beauv.*,	" "
H. riparium, *Hedw.*,	" "
var. cariosum, *Sull.*,	Ill

HEPATICAE.

RICCIACEAE.

RICCIA, *Mich.*

R. sorocarpa, *Bisch.*,	Fulton, Menard.
R. lescuriana, *Aust.*,	" "
R. natans, *L.*,	" "
R. lutescens, *Schwein.*,	" "
R. fluitans, *L.*,	Fulton.
var. canaliculata, *Hoffm.*,	"
var. sullivanti, *Aust.*,	Menard.
R. frostii, *Aust.*,	Fulton.

ANTHOCEROTEAE.

ANTHOCEROS, *Mich.*

A. punctatus, *L.*,	Fulton, Menard.
A. laevis, *L.*,	Fulton, Menard, Union.
var. major,	Fulton.
A. orbicularis, *Schwein.*,	"

MARCHANTIACEAE.

MARCHANTIA, *L.*

M. polymorpha, *L.*,	Fulton, Menard.

CONOCEPHALUS, *Hill.*

C. conicus, *L.*,	Fulton, Menard, Union.

ASTERELLA, *Beauv.*

A. hemisphaerica, *L.*,	Fulton, Menard, Union.

DUVALIA, *Nees.*

D. barbifrons, *Bisch.*,	Fulton, Menard.

FIMBRIARIA, *Nees.*

F. tenella, *Nees*,	Fulton, Menard.

JUNGERMANNIACEAE.

ANEURA, *Dumort.*

A. pinguis, *L.*,	Fulton.
A. sessilis, *Spreng.*,	Menard, Johnson.
A. multifida, *L.*,	Fulton.
A. latifrons,	Menard.

CHILOSCYPHUS, *Corda.*

C. ascendens, *Sull.*,	Fulton, Menard, Johnson

LOPHOCOLEA, *Nees.*

L. bidentata, *L.*,	Fulton.
L. heterophylla, *L.*,	"
L. macouni, *Aust.*,	Fulton, Johnson.
L. minor, *Nees*,	Menard, Fulton.

BLEPHAROSTOMA, *Dumort.*

B. trichophyllum, *L.*,	Fulton.

CEPHALOZIA.

C. sullivantiae, *Aust.*,	Johnson.
C. divaricata, *Engl. Bot.*,	Fulton.
C. bicuspidata, *L.*,	"
C. curvifolia, *Dicks.*,	Fulton, Menard, Union, Johnson.
C. connivens, *Dicks.*,	Ill.
C. albescens, *Hook.*,	"

HARPANTHUS, *Nees.*

H. scutatus, *Mitt.*,	Union, Johnson

JUNGERMANNIA, *L.*

J. schraderi, *Mart.*,	Fulton, Menard, Union Johnson.
J. hyalina, *Lyell*,	Fulton.

LEPTOSCYPHUS.

L. taylori, *Hook.*,	Fulton.

SCAPHANIA, *Lindenberg.*

S. nemorosa, *L.*,	Johnson.

FRULLANIA, *Raddi.*

F. grayana, *Mont.*,	Menard.
F. squarrosa, *Nees*,	S. Ill.
F. aeolotis, *Nees*,	Fulton, Menard.
F. virginica, *Gottsche*,	" "
F. eboracensis, *Gottsche*,	" "

MADOTHECA, *Dumort.*

M. thuja, *Dicks.*,	Fulton, Menard.
M. porella, *Dicks.*,	" "

RADULA, *Nees.*

R. complanata, *L.*,	Menard.

BLEPHAROZIA.

B. ciliaris, *L.*,	Fulton, Menard.

CALYPOGEIA, *Raddi.*

C. trichomanis, *Dicks.*,	Menard.

LICHENES.

USNEEI.

Ramalina, *Ach.*

R. calicaris, *Fr.*,	Fulton, Menard, S. Ill.
var. fraxinea, *Fr.*,	Fulton, Menard.

Cetraria, *Ach.*, *Fr.*

C. cilaris, *Ach.*,	Fulton, Menard.

Usnea, *Ach.*

U. barbata, (*L.*) *Fr.*,	Fulton, Menard, S. Ill.
var. florida, *Fr.*,	Menard.
var. strigosa, *Ach.*,	Fulton.
var. rubiginosa, *Mich.*,	Menard.

Alectoria, (*Ach.*) *Nyl.*

A. jubata, (*L.*) *Fr.*, var. chalybeiformis, *Ach.*,	Fulton.

PARMELIEI.

Theloschistes, *Norm.*, *Tuck.*

T. parietinus, (*L.*) *Norm.*,	Menard.
T. concolor, (*Dicks*,)	Fulton, Menard.

Parmelia, (*Ach.*,) *D. N.*

P. perforata, *Ach.*,	Fulton, Menard.
var. crinita, (*Ach.*) *Tuck.*,	" "
P. perlata, (*L.*) *Ach.*,	" "
var. olivetorum, *Ach.*,	" "
P. tiliacea, (*Hoffm.*) *Flk.*,	" "
P. borreri, *Turn.*,	" "
var. rudecta, *Tuck.*,	Menard.
P. saxatilis, (*L.*) *Fr.*,	Fulton, Menard, Johnson.
var. rosaeformis, *Ach.*,	Menard.
P. laevigata, *Ach.*,	"
P. aurulenta, *Tuck.*,	"
P. colpodes, *Ach.*,	"

P. caperata, (*L.*) *Ach.*,	Fulton, Menard, S. Ill.
P. conspersa, (*Ehrh.*) *Ach.*, var. stenophylla, *Ach.*,	Menard.
P. olivacea, (*L.*) *Ach.*	Fulton, "
var. aspidota, *Ach.*	"

PHYSCIA, (*Fr.*) *Th. Fr.*

P. aquila, (*Ach.*) *Nyl.* var. detonsa, *Tuck.*,	Union.
P. pulverulenta, (*Schreb.*) *Nyl.*,	Fulton, Menard, S. Ill.
P. speciosa, (*Wulf. Fr.*) *Nyl.*,	" " "
var. hypoleuca, *Ach.*,	Fulton, Menard.
P. stellaris, (*L.*) *Nyl.*,	" "
var. tribacia, *Fr.*,	" "
P. cæsia, (*Hoffm.*) *Nyl.*,	Fulton.
var. stellata, *Fr.*,	Fulton, Menard.
P. obscura, (*Ehrh.*) *Nyl.*,	" "
var. ciliata, *Schaer.*,	" "
var. agglutinata, *Schaer.*,	" "

PYXINE, *Fr.*

P. cocoes, (*Sw*)., *Nyl.*,	Fulton.
var. sorediata, *Tuck.*,	Fulton, Menard.

PELTIGEREI.

STICTA, (*Schreb.*,) *Del.*

S. herbacea, *Ach.*, (?)	Menard.

NEPHROMA, *Ach.*

N. laevigatum, *Ach.*,	Union, Johnson.

PEITIGERA, (*Hoffm.*) *Fee.*

P. canina, (*L.*) *Hoffm.*,	Fulton, Menard.
P. polydactyla, (*Neck.*) *Hoffm.*,	"

PANNARIEI.

HEPPIA, *Naeg.*

H. despreauxii, *Mont.*,	Fulton, Menard.

PANNARIA, (*Del.*) *Tuck.*

P. microphylla, (*Sw.*) *Del.*,	Union, Johnson
P. leucosticta, *Tuck.*,	" "

P. crossophylla, *Tuck.*,	S. Ill.
P. molybdaea, *Pers.*, var. cronia, *Tuck.* (*Southern specimens in fruit*,)	Fulton, Johnson.
P. nigra, (*Huds.*) *Nyl.*	Fulton, Menard, S. Ill.
P. byssina, (*Hoffm.*) *Tuck.*,	Fulton, Menard.

COLLEMEI.

Ephebe, (*Fr.*) *Tuck.*

E. pubescens, *Fr.*,	Menard.

Synalissa, *Fr.*

S. schaereri, *Mass.*,	Fulton, Menard, S. Ill.
S. phaeococca, *Tuck.*,	Fulton.

Collema, (*Hoffm.*) *Fr.*

C. pycnocarpum, *Nyl.*,	Fulton, Menard.
C. cyrtaspis, *Tuck.*,	" "
C. microphyllum, *Ach.*,	Menard, Union
C. verruciforme, *Ach.*,	Menard.
C. leptaleum, *Tuck.*,	"
C. flaccidum, *Ach.*,	Fulton, Johnson.
C. nigrescens, (*Huds.*) *Ach.*,	Fulton, Menard.
C. pulposum, (*Bernh.*)	Fulton, Menard, Johnson.
var. tenax, *Ach.*,	Ill.
C. limosum, *Ach.*,	Fulton, Menard.
C. arenosum, (*Wulf.*) *Schaer.*,	Menard.
C. pustulatum, *Ach.*,	Johnson.

Leptogium, *Fr.*

L. subtile, *Nyl.*,	Fulton, Menard, Union.
L. minutissimum, *Flk.*,	Menard.
L. lacerum, (*Sw.*) *Fr.*,	Fulton, "
var. bolacinum, *Schaer.*,	"
L. pulchellum, (*Ach.*) *Nyl.*,	Fulton, Menard, Johnson.
L. tremelloides, *Fr.*,	Fulton, Menard.
L. cæsiellum, *Tuck.*, *ined. n. sp.*,	" "
L. chloromelum, (*Sw.*) *Nyl.*,	" "
L. myochroum, (*Ehrh.*) *Schaer.*,	S. Ill.
var. saturninum, (*Dicks.*) *Tuck.*,	Johnson.
L. dactylinum, *Tuck.*,	Fulton.

LECANOREI.

Placodium, (*DC.*,) *Naeg. & Hepp.*

P. sideritis, *Tuck.*,	Fulton.
P. vitellinum, (*Ehrh.*) *Hepp.*,	Fulton, Menard.
P. cerinum, (*Hedw.*) *Naeg*,	Fulton, Menard, S Ill.
P. aurantiacum, (*Light.*) *Naeg.*,	Fulton, Menard, Johnson.
P. ferrugineum, (*Huds.*,) *Hepp.*,	Fulton, Menard, S. Ill.
var. nigricans, *Tuck.*,	Fulton.
P. camptidium, *Tuck.*	Fulton, Menard.

Lecanora, *Ach.*, *Tuck.*

L. muralis, (*Schreb.*) *Schaer.*,	S. Ill.
L. tartarea, (*L.*) *Ach.*,	"
L. subfusca, (*L.*) *Ach.*,	Fulton, Menard, Union, Johnson.
var. discolor, *Fr.*,	Fulton.
L. varia, (*Ehrh.*) *Fr.*,	Fulton, Menard.
var. aitema, *Ach.*,	Fulton.
var. sarcopis, *Wahl.*,	"
L. elatina, *Ach.*, var. ochrophaea, *Tuck.*,	"
L. cinerea, *L.*	S. Ill.
L. cervina, *Pers.*, var. eucarpa, *Nyl*,	"
var. pruinosa, *Ach.*,	Fulton.

Rinodina, *Mass.*

R. sophodes, (*Ach.*) *Mass.*,	Fulton, Menard.
var. confragosa. *Nyl.*,	Fulton, Johnson.
R. ascociscana, *Tuck.*,	Fulton, Menard.
R. albo-atra, *Fl.*,	Ill.
R. constans, (*Nyl.*) *Tuck.*,	Fulton.

Pertusaria, *D. C.*

P. pertusa, (*L.*) *Ach.*,	Menard, Johnson.
P. leioplaca, (*Ach.*) *Schaer.*,	Fulton, Menard.
P. velata, (*Turn.*) *Nyl.*,	" "
P. pustulata, (*Ach.*) *Nyl.*,	" "
P. wulfenii, *DC.*,	" "
P. globularis, *Ach.*,	S. Ill.

Conotrema, *Tuck.*

C. urceolatum, (*Ach.*) *Tuck.*,	Fulton, Menard.

Gyalecta, *Ach.*

G. pineti, (*Schrad.*) *Fr.*,	Fulton, Menard.
G. trivialis, *Willey, ined. n. sp.*,	Fulton.

CLADONIEI.

Cladonia, *Hoffm.*

C. alcicornis, *Fr.*,	Johnson.
C. pyxidata, *Fr.*,	Fulton, Menard.
var. symphycarpa, *Fr.*,	Menard.
C. cariosa, (*Ach.*) *Spreng.*,	Fulton.
C. fimbriata, (*L.*) *Fr.*,	Fulton, Menard.
var. tubaeformis, *Hoffm.*,	Fulton.
var. adspersa, *Tuck.*,	Fulton, Menard.
C. gracilis, (*L.*) *Fr.*,	" "
var. verticillata, *Fr.*,	" "
C. mitrula, *Tuck.*,	" "
C. turgida, (*Ehrh.*) *Hoffm.*,	" "
C. furcata, (*Huds.*) *Fr.*	Fulton, Menard, Johnson, Union.
var. crispata, *Flk.*,	Fulton, Menard.
var. racemosa, *Flk.*,	Menard.
var. subulata, *Flk.*.,	"
C. squamosa, *Hoffm.*,	Fulton, Menard.
var. delicata,, *Fr.*	" "
var. cæspiticia, *Nyl*,,	Johnson.
C. rangiferina, (*L.*) *Hoffm.*,	Fulton, Menard, Johnson.
C. uncialis, (*L.*) *Fr.*,	Johnson.
C. macilenta, *Hoffm.*,	Fulton, Menard.
C. muscigena, *Eschw.*,	Menard
C. cristatella, *Tuck.*,	Fulton, Menard.
var. ramosa, *Tuck.*,	" "

LECIDEEI.

Biatora, *Fr.*

B. rufo-nigra, *Tuck.*,	S. Ill.
B. coarctata, *Th. Fr.*,	Fulton.
B. flexuosa, *Fr.*,	"
B. parvifolia, *Pers.*,	S. Ill.
B. russula, (*Ach.*) *Mont.*,	Fulton.
B. sanguineo-atra, (*Fr.*) *Tuck.*,	Fulton, Menard.
B. carnulenta, *Tuck.*,	Fulton.
B. exigua, (*Chaub.*) *Fr.*,	Fulton, Menard, Union.
B. uliginosa, (*Schrad.*) *Fr.*,	Fulton, Menard.
B. rudis, *Willey*,	Fulton.
B. peliaspis, *Tuck.*,	"
B. atro-purpurea, (*Mass.*) *Tuck.*,	"
B. hypnophila, (*Turn.*) *Tuck.*,	Fulton, Menard.

B. rubella, (*Ehrh.*)	Fulton, Menard, Union.
var. spadicea, *Ach.*,	Fulton, Menard.
var. suffusa, *Fr.*,	" "
var. inundata, *Fr.*,	Fulton.
B. umbrina, (*Ach.*) *Tuck.*, var. bacillifera, *Nyl.*, f. muscorum, *Sev.*,	"
B. chlorosticta, *Tuck.*,	Johnson.
B. chlorantha, *Tuck.*,	Fulton.
B. campestris, *Fr.*,	Fulton, Menard.
B. fossarum, (*Duf.*) *Mont.*,	" "
B. cyphalea, *Tuck.*,	" "
B. geophana, *Nyl.*	Fulton.
B. resinae, *Fr.*,*	Fulton, Menard.

LECIDEA, (*Ach.*)

L. albo-cœrulescens, *Fr.*,	Union.
L. enteroleuca, *Fr.*,	Menard, Johnson.
L. tessellina, *Tuck.*,	S. Ill.
L. myriocarpoides, *Nyl.*,	Fulton.

BUELLIA, (*D. N.*) *Tuck.*

B. lactea, *Mass.*,	S. Ill.
B. atro-alba, (*Fl.*) *Th. Fr.*, var. chlorospora, *Nyl.*,	"
B. parasema, (*Ach.*) *Kbr.*,	Fulton, Menard.
B. myriocarpa, (*D C.*) *Madd.*,	Fulton.

OPEGRAPHEI.

OPEGRAPHA, (*Humb.*) *Ach.*, *Nyl.*

O varia, (*Pers.*) *Fr.*,	Fulton, Menard.
O. vulgata, (*Ach.*) *Nyl.*,	Union.

GRAPHIS, *Ach.*, *Nyl.*

G. scripta, (*L.*) *Ach.*,	Fulton, Menard, Union.
G. eulectra, *Tuck.*,	Menard.
G. dendritica, *Ach.*,	Fulton, "

ARTHONIEI.

ARTHONIA, *Ach.* *Nyl.*

A. pyrrhula, *Nyl.*,	Fulton, Menard.
A. lecideella, *Nyl.*,	" "
A. patellulata, *Nyl.*,	Fulton.
A astroidea, (*Ach.*) *Nyl.*	
var. epipasta, *Nyl.*,	Fulton, Menard.

*"Probably a fungus."—*Willey.*

A. punctiformis, *Ach.*,	Fulton, Menard, Union.
A. polymorpha, *Ach.*,	Fulton.
A. tædiosa, *Nyl.*,	Fulton, Menard, S. Ill.
A. spectabilis, *Fl.*,	Fulton, Menard.

MYCOPORUM, (*Fl.*) *Nyl.*

M. pycnocarpum, *Nyl.*,	Fulton, Menard, Union.

CALICIEI.

ACOLIUM, (*Fee.*) *D N.*

A. tigillare, (*Ach.*) *D N.*	Menard.

CALICIUM, *Pers. Ach. Fr.*

C. subtile, *Fr.*,	Fulton, Menard.
C. trachelinum, *Ach.*,	" "
C. curtum, *Turn. & Borr.*,	Fulton.
C. roscidum, *Flk.*, var. trabinellum, *Nyl.*,	"
var. dosodes, *Tuck., ined.*,	"
C. microcephalum, (*Sm.*) *Turn. & Borr.*,	"
C. populneum (?), *DeBrogn.*,	S. Ill.
C. tubiforme, *Mass.*,	Johnson.
C. turbinatum, *Pers.*,	Fulton.

CONIOCYBE, *Ach.*

C. pallida, (*Pers.*) *Fr.*,	Menard.

ENDOCARPEI.

ENDOCARPON, *Hedw. Fr.*

E. miniatum, (*L.*,) *Schaer.*,	Union.
var manitense, *Tuck.*,	Johnson.
E. arboreum, *Schwein.*,	Fulton, Menard.
E. cinereum, *Nees.*,	Fulton.
E. rufescens, *Ach.*,	Fulton, Menard.
E. hepaticum, *Ach.*,	S. Ill.
E. pusillum, *Hedw.*,	Fulton, "

VERRUCARIEI.

SEGESTRIA, *Fr.*

S. lauveri, (*Fl.*) *Tuck.* *Found on stones, rails and bark.*	Fulton, S. Ill.

STAUROTHELE, *Norm.*

S. diffractella, (*Nyl.*) *Tuck.*,	S. Ill.

SAGEDIA, (*Mass. Kbr.*) *Tuck.*

S. cestrensis, *Tuck.*,	S. Ill.
S. lactea, *Kbr.*,	Fulton.

VERRUCARIA, (*Pers.*) *Tuck.*

V. epigæa, (*Pers.*) *Ach.*,	Fulton, Menard.
V. nigrescens, *Pers.*,	Fulton.
V. fuscella, *Fr.*,	S. Ill.
V. rupestris, *Schrad.*,	Fulton, "
V. muralis, *Ach.*,	Adams.
V. pyrenophora, (*Ach.*) *Nyl.*,	Fulton.

PYRENULA, *Ach.*

P. thelena, (*Ach.*) *Tuck.*,	Fulton, Menard.
var. micula, *Fl.*,	Fulton.
P. punctiformis. (*Ach.*) *Naeg.*,	Fulton, Menard.
P. nitida, *Ach.*,	Menard, Fulton.
P. subcinerea, (*Nyl.*) *Tuck.*,	"
P. gemmata, (*Ach.*) *Naeg.*,	"
P. leucoplaca, (*Walbr.*) *Kbr.*,	Fulton, Menard.
P. glabrata, (*Ach.*) *Mass.*,	Fulton, Union.
P. lactea, (*Mass.*) *Tuck.*,	Fulton, Menard.

INDEX TO GENERA.

A CATALOGUE OF THE FISHES OF ILLINOIS.

By Prof. DAVID S. JORDAN.

This catalogue is based primarily on the collections in the Illinois State Laboratory of Natural History, at Normal. These collections consist (*a*) of the material on which Mr. Nelson's* list was based, and (*b*) of a large collection made by Professor Forbes during the past summer (1877), chiefly in the streams of southern Illinois. The writer's own collections in Illinois and adjacent states have also been drawn upon, as well as those contained in the United States National Museum. The various scattered notices of Illinois fishes have also been brought together as far as possible, thus giving all that is at present known of the distribution of the species within the limits of the state.

Reference has been made throughout this paper to the second edition of the author's Manual† of Vertebrates, (quoted as "M. V.,") in which nearly all the species here mentioned are described. No synonomy is given except that of Mr. Nelson's list, above mentioned, of which paper the present may be considered as, in a sense, a revised edition.

A few species either new to science or new to our fauna and therefore not noticed in the Manual, are here described in full.

In all cases where I have found exact record of localities of species, these have been inserted. Species not yet taken in Illinois, but included in the catalogue on the strength of our general knowledge of their range, are indicated by a star (*).

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*A Partial Catalogue of the Fishes of Illinois, by E. W. Nelson, Bulletin No. 1, Illinois Museum of Natural History, October, 1876.

†A Manual of the Vertebrate Animals of the Northern United States, including the district east of the Mississippi River and north of North Carolina and Tennessee—exclusive of Marine Species, by David Starr Jordan, M. D., Ph. D., professor of Natural History in Butler University. Second edition, revised and enlarged. Chicago—Jansen, McClurg & Co. 1878.

Subclass, TELEOSTEI.

Order, TELEOCEPHALI.

Suborder, ACANTHOPTERI.

Family ETHEOSTOMATIDÆ, (the Darters.)

Genus *PLEUROLEPIS*, Agassiz.

1. *Pleurolepis pellucidus* (Baird) Ag. Sand Darter, (M. V. 219., Nelson, 35).

Abundant in clear sandy streams, wherever such occur; therefore generally absent in the prairie region, but occurring in the Wabash valley and in the northwestern part of the state. The genus *Pleurolepis*, like *Ammocrypta*, has usually but one anal spine, although two have been generally ascribed to it. Pine Cr. and Rock R., in Ogle Co.

2. *Pleurolepis asprellus* Jordan (sp. nov.) Rough Sand Darter.

A species similar in form to *P. pellucidus*, but less transparent and much more completely scaled. The size is also much larger.

Body very long and slender, nearly cylindrical, about as in *P. pellucidus*, the depth about 8 in the length. Caudal peduncle long and slender, its length nearly 4 times in total. Head long and rather slender, $4\frac{1}{5}$ in length; eyes very large, high up and very close together, shorter than snout, having considerable vertical range.

Mouth not large, sub-terminal, horizontal, the upper jaw rather the longer. Upper jaw sub-protractile, the furrow separating it from the forehead very distinct laterally, but obliterated mesially, the skin covering the middle of the intermaxillaries being continuous with that of the rest of the forehead. Cheeks, opercles and sides of the crown covered with pectinated scales; opercular spine well developed. Teeth as usual, rather feeble. Squamation much more complete than in *P. pellucidus*. Sides and back with well-developed, closely imbricated scales, which are not imbedded as in *P. pellucidus*; the scales larger on the caudal peduncle than anteriorly. Jugular region, and belly between ventrals and anal, entirely naked; spac between bases of ventrals scaled; back of neck scaly; lateral line wells developed, with about 98 scales, 10 series above the lateral line. Fine large, the dorsals well separated, the spinous dorsal high, its anterior rays highest; second dorsal smaller and smaller than anal. Anal fin with a single rather flexible spine; caudal lunate, more concave than usual in darters. Pectorals and ventrals large, their tips about even, neither quite reaching the vent. Coloration of smaller specimens much as in *P. pellucidus*, accord-

ing to Prof. Forbes rather opaque in life; sides with 8 to 10 dark, squarish blotches, quite small and far apart; a blackish shade forward from eye and a dusky shade across opercle.

Numerous specimens in the State collection, some about $2\frac{1}{3}$ inches long, taken by Prof. Forbes in the Little Wabash River, (a sandy stream,) in Effingham Co., in July. Two others, larger, one of them, the type of this description, $4\frac{1}{2}$ inches long, collected by Mr. C. K. Worthen, in a small rocky tributary of the Mississippi, in Hancock Co. These were described as *very highly colored* when fresh, presenting "almost all the colors of the rainbow."

Genus *PERCINA*, Haldeman.

3. *Percina caprodes* (Raf.) Grd. LOG PERCH. HOG FISH. (M. V. 219; B. I. M. 36.)

   In clear rapid waters; probably generally distributed. Vermilion R., Calumet R., Wabash R., Pine Cr., (Ogle Co.)

4. **Percina manitou* Jordan. MANITOU DARTER. (M. V. 220.)

   From Lake Manitou, a tributary of the Wabash in Indiana; also from Wisconsin.

Genus *ALVORDIUS*, Girard.

5. *Alvordius maculatus* Grd. BLACK SIDED DARTER; BLENNY DARTER. (M. V. 220; *Etheostoma blennioides* Nelson, 35.)

   In clear waters—generally distributed. Ogle Co.; Tazewell Co.; Clear Cr., Union Co.

6. *Alvordius phoxocephalus* (Nelson) Cope and Jordan; SHARP-NOSED DARTER. (M. V. 221, *Etheostoma phoxocephalum* Nelson, 35.)

   Illinois River; a few specimens in the collection; also from Tennessee and Kansas.

Genus *ERICOSMA*, Jordan.

7. **Ericosma evides* Jordan & Copeland. GILDED DARTER. (M. V. 221. *Etheostoma evides* Nelson 36.)

   At present known only from White River, a tributary of the Wabash in Indiana.

Genus *IMOSTOMA*, Jordan.

8. *Imostoma shumardi* (Grd.) Jordan. BIG-HEADED DARTER. (M. V. 222.)

   Specimens in the Indiana State collection from Wabash River in Crawford Co., and in the National Museum from the Illinois River in La Salle Co.

Genus *RHEOCRYPTA*, Jordan.

9. **Rheocrypta copelandi* Jordan. COPELAND'S DARTER. (M. V. 222.) Known only from White River, near Indianapolis.

Genus *DIPLESIUM*, Rafinesque.

10. *Diplesium blennioides* (Raf.) Jordan. GREEN-SIDED DARTER. (M. V. 222.)

Abundant in the Wabash valley, Crawford Co.

Genus *BOLEOSOMA*, Dekay.

11. *Boleosoma olmstedi* (Storer) Agassiz. TESSELLATED DARTER. (M. V. 224; Nelson, 35). Lake Michigan, Ogle Co.

12. *Boleosoma maculatum* Agassiz. JOHNNY DARTER (M. V. 224; *Boleosoma brevipinne* Nelson, 36.)

Common throughout the state, in clear streams. Pine Cr., Ogle Co.; Illinois R., Pekin; Normal; Drury Cr., Union Co.; Clear Cr.

[13. *Boleosoma camurum*, Forbes, n. s.

In re-examining the collections of the Laboratory for the purpose of adding to this paper the details of distribution and other minor points, I made a few observations on some *Etheostomatidae* and *Cyprinidae* which seem worthy of record, and I therefore insert them here, at the suggestion of Dr. Jordan.

Specimens from several localities in the state, mixed sometimes with *Boleosoma maculata* and sometimes with *Boleichthys eos*, prove, on closer examination, to be a *Boleosoma* quite distinct from *maculata*, and apparently undescribed.

The general appearance is much like that of *maculata*, but the lateral line is incomplete, the species is more slender, has a greater number of vertical rows of scales, a blunt nose and a scaly head.

The length is from 45 to 50 mm. Depth $5\frac{1}{2}$ to 6 in length, caudal peduncle $3\frac{1}{2}$, head 4 to $4\frac{1}{2}$. Eye $3\frac{2}{3}$ in head, nose $\frac{2}{3}$ eye, and almost truncate. Mouth inferior, horizontal, upper jaw the longer, and decidedly protractile. There are no naked areas, except a narrow strip before the dorsal. Vertical rows of scales 54 to 57, with the lateral line usually extending over from 23 to 35 scales. 5 longitudinal rows above lateral line. In a few specimens 35 to 50 mm. long, there is only a trace of a lateral line on 4 or 5 scales. Scales smaller before dorsal, about $\frac{4}{5}$ those on sides.

D. IX or X—10 to 12, A. I—8 or 9. Upper D. half as high as long, about $\frac{5}{6}$ height of 2d D., and contiguous to it. Second $\frac{7}{10}$ length of first, and $\frac{2}{5}$ longer than anal. Anal spine weak and short, length of fin $\frac{4}{5}$ its height. Ventrals and pectorals reach the same point, $\frac{2}{3}$ to vent.

Color in alcohol like that of *B. maculata.* A row of obout 10 irregular blotches along the side,—sometimes obscure, especially before—and six larger ones on the back. Many smaller, irregular, angular specks between these rows. Belly immaculate. Stripe before eyes and blotch on opercle. Median fins banded, others plain. Cache R. and Clear Cr., Union Co.; Johnson Co.; Pekin.

This species makes it necessary to drop the complete lateral line as a character of *Boleosoma.* In fact, this is often wanting on four or five posterior scales in *B. maculata.* S. A. F.]

Genus *NANOSTOMA*, Putnam.

14. *Nanostoma zonale* (Cope) Jordan. ZONED DARTER. (M. V. 225.)

Many specimens from Pine Creek in Ogle Co.

Genus *NOTHONOTUS*, Agassiz.

15. **Nothonotus camurus* (Cope) Jordan. BLUE-BREASTED DARTER. (M. V. 225; *Poecilichthys niger* Nelson, 34.)

A few specimens from White River in Indiana.

Genus *PŒCILICHTHYS*, Agassiz.

16. *Pœcilichthys variatus* (Kirtland) Agassiz. BLUE DARTER. (M. V. 226; *Pœcilichthys cæruleus* Nelson, 34.)

Generally common in clear or gravelly streams—especially so in the Wabash Valley; Farmington; Rock R., Ogle Co; Pekin, Ill.

17. *Pœcilichthys spectabilis* Agassiz. STRIPED BLUE DARTER. (M. V. 227; Nelson, 34.)

With the preceding; rather less common and more fond of ascending small streams; often found in waters with a muddy bottom. Effingham Co.; Mackinaw Cr., McLean Co.; Pine Cr., Ogle Co.; Cache R., Drury Cr., Clear Cr., and mud holes in Union Co.

[18. *Pœcilichthys asprigenis* Forbes, n. s.

Among some specimens from Pekin, Ill., whose label as *Pœcilichthys spectabilis* had apparently served to disguise them, I observed a number with scaly cheeks. Dr. Jordan has decided that these are neither *spectabilis*, nor *jessiæ*, and I have therefore described the series as a new species, although the wide variation of so-called specific characters presented by them suggests that several species of this genus may ultimately have to be merged. I have not been able, however, with a large number of specimens to trace the one wholly into the other, and I therefore leave them distinct for the present.

General appearance much like that of *P. spectabilis*, from which it differs in the scaly cheeks, the more complete lateral line and the greater number of vertical rows of scales. In *spectabilis* the cheeks are either wholly bare, or a few scales appear behind and below the eye. In *asprigenis* they are either wholly covered, or naked only on the lower fourth. The vertical rows vary in my specimens of *spectabilis* from 38 to 43 (counting only complete rows),—in *asprigenis* from 48 to 50. In the former, the lateral line extends over from 25 to 31 scales—in the latter from 34 to 41.

The head is small and pointed, the eye large, (longer than snout,) the outlines regularly curved, the body compressed and rather deep, the mouth terminal, oblique, and the jaws about even.

The dorsal fins are sometimes separated by distances varying from the length of half a scale to a scale and a half, but are occasionally quite continuous, the two being united by membrane.

Length 35 to 45 mm. Depth $4\frac{1}{4}$ to $4\frac{3}{4}$ in length; head $3\frac{3}{4}$ to 4; eye in head $3\frac{1}{2}$ to 4; nose about $\frac{2}{3}$ the eye. Width at pectorals 8 to 10 in length; at middle of second dorsal, 12 to 15. The caudal peduncle is twice long as high. Longitudinal rows $\frac{5}{8}$. Breast always naked, opercle wholly as scaly, back wholly scaled before the dorsal, or a narrow strip left bare.

The first dorsal consists of from 9 to 12 spines. Its height is from $\frac{1}{2}$ to $\frac{1}{3}$ its length, and $\frac{2}{3}$ the height of the second dorsal. The latter contains from 10 to 12 rays, of which, in one case, the first was a stout sharp spine (XI—I, 11). Its length is $\frac{2}{3}$ that of the first, and $\frac{3}{5}$ greater than that of the anal. The anal consists of two spines and 7 or 8 soft rays, the longest ray reaching to the middle of the caudal peduncle. 14 specimens examined. Taken in small creek near Pekin, Ill.

The naked cheeks and contiguous dorsals are evidently not good generic characters of *Pœcilichthys*, S. A. F.]

Genus *ETHEOSTOMA*, Rafinesque.

19. *Etheostoma flabellare* Rafinesque. FAN-TAILED DARTER. (M. V. 227; *Pœcilichthys flabellatus* Nelson, 34.)

    In clear waters in the southern part of the state. Specimens from Clear Cr., Union Co., and from Wabash River.

    Var. *lineolatum* (Agassiz) Jordan. LINED DARTER. (M. V. 227; *Pœcilichthys lineolatus* Nelson 34.) Clear streams in northern Illinois. Rock River, Ogle Co. Finish.

20. **Etheostoma squamiceps* Jordan. SCALY-HEADED DARTER. (M. V. 228.)

    Known only from western Kentucky.

Genus *BOLEICHTHYS*, Girard.

21. *Boleichthys eos* Jordan & Copeland. RED SIDED DARTER. (M. V. 228; Nelson, 34.)

    In clear cold streams throughout the state. Effingham Co., Johnson Co.

[22. *Boleichthys elegans*, Gir.

Several specimens from Union and Johnson counties, apparently belong to this species. The following description is made up from Dr. Jordan's account of the species in Ann. N. Y. Lyc., XI, 308, modified to include my larger specimens, some of which are 2 inches long.

Body short, chubby and compressed, bearing some resemblance in form to *Microperca punctulata*. Mouth moderate, with equal jaws.

Dorsal fins usually distinctly separate, the second $\frac{2}{3}$ as long as the first and twice as long as anal. Vertical rows of scales varying from 42 to 56. Lateral line distinct on from 13 to 30 scales, arched high over pectorals, running parallel with the rounded nuchal region, separated from the dorsal fin by but 3 rows of scales. Head and neck scaly, throat bare, as well as a small space behind pectorals and ventrals.

Head $3\frac{3}{4}$ to 4 in length, depth $4\frac{3}{4}$. Eye 3 to 4 in head Width at pectorals (in adult) $6\frac{3}{4}$ in length. Fin rays, D. IX or X—9 to 11; A. II—7 or 8. Color greenish with dark specks, in Illinois specimens with about 10 dorsal bars, and 6 lateral blotches on posterior half of side. Dark line before eye and in adults another below eye, and an opercular blotch. S. A. F.]

Genus *MICROPERCA*, Putnam.

23. *Microperca punctulata* Putnam. Least Darter. (M. V. 229; Nelson, 34.)

In clear streams. Drury Cr., Union Co.; Crystal Lake, McHenry Co.; Kane Co.

Family PERCIDAE, (the Perches.)

Genus *PERCA*, Linnæus.

24. *Perca americana* Schranck. Common Yellow Perch, Ringed Perch. (M. V. 229; *Perca flavescens* Nelson, 36.)

Very abundant in Lake Michigan and all its tributaries, and to a less degree in all the tributaries of the Mississippi River in the northern third of the state. In the southern part of the state it is very rarely or never found, its range, like that of *Eupomotis aureus*, being bounded by lines of latitude. Peoria and Pekin, Ill.; L. Mich.

Genus *STIZOSTETHIUM*, Rafinesque.

25. *Stizostethium canadense* (Smith) Jordan. Sauger. Sand Pike, Ground Pike, Gray Pike (M. V. 230. *Stizostedium griseum* Nelson, 36.)

Generally abundant in the lakes and all the larger streams. L. Mich.; Ill. R. at Peoria, &c.

26. *Stizostethium vitreum* (Mitch.) Jordan & Copeland. WALL-EYED PIKE, SALMON, DORY, GLASS-EYE, YELLOW PIKE. (M. V. 230; *Stizostedium americanum* Nelson, 36.)

Generally abundant in the lakes and larger bodies of water, especially northward. Ill. R. at Peoria.

var. *salmoneum* (Raf.) Jor. WHITE SALMON, BLUE PIKE. (M. V. 230. Nelson, 36.) Ohio River and its larger tributaries.

Family LABRACIDÆ, (the Bass.)

Genus *ROCCUS*, Mitchill.

27. *Roccus chrysops* (Raf.) Gill. WHITE BASS. (M. V. 232; Nelson, 36.)

Generally abundant in the larger streams northward. Lake Michigan; Quincy; Henry.

Genus *MORONE*, Mitchill.

28. *Morone interrupta* Gill. SHORT-STRIPED WHITE BASS (M. V. 232: Nelson, 36.) Common in the southern half of the state in the larger streams. Illinois R. at Henry; Mackinaw Creek, McLean Co.; Cairo.

Family CENTRARCHIDÆ, (the Sun-fishes.)

Genus *MICROPTERUS*, Lacepede.

29. *Micropterus pallidus* (Raf.) Gill & Jordan. LARGE-MOUTHED BLACK BASS, OSWEGO BASS (M. V. 236; *Micropterus nigricans* Nelson, 36)

Everywhere abundant, especially northward; found in sluggish waters and small streams, more frequently than the next. Lake Michigan; Rock R., Ogle Co.; Calumet R.; Crystal Lake: Running Lake and Clear Creek, Union Co.; Wabash River; Mackinaw Cr., McLean Co.

30. *Micropterus salmoides* (Lac.) Gill. SMALL-MOUTHED BLACK BASS, MOSS BASS. (M. V. 236; Nelson, 37.)

Everywhere common, seeking the river channels more than the preceding does. Rock R., Ogle Co.; Ill. R.

Genus *AMBLOPLITES*, Rafinesque.

31. *Ambloplites rupestris* (Raf.) Gill. ROCK BASS, RED EYE, GOGGLE EYE. (M. V. 237; Nelson, 37.)

Generally abundant throughout the state. McLean Co.; Henry; Ogle Co.

Genus *CHÆNOBRYTTUS*, Gill.

32. *Chænobryttus gulosus* (C. & V.) Gill. WAR-MOUTH, BLACK SUN-FISH. (M. V. 237; Nelson, 37.)

Rather common. Very abundant in southern Illinois. Prof. Forbes has specimens from Illinois River, and I have taken it in Lake Michigan, and in lakes of Northern Indiana tributary to Wabash River. Mackinaw Cr.; Big L., Jackson Co.

Genus *APOMOTIS*, Rafinesque.

33. *Apomotis cyanellus* (Raf.) Jor. BLUE-SPOTTED SUN-FISH. (M. V. 239; *Telipomus cyanellus* and *T. microps* Nelson, 37.)

Generally abundant, ascending small streams. Embarras River, Calumet R., Illinois R., Cache R., mud-holes on bottoms in Union Co. and Johnson Co., Effingham Co., all small streams in McLean Co.; Fountain Bluff, Jackson Co.

Genus *LEPIOPOMUS*, Rafinesque.

34. *Lepiopomus macrochirus* Raf. CHAIN-SIDED SUN-FISH. (M. V. 239; *Telipomus nephelus* Nelson, 37.)

Not very common; I have one specimen from Illinois River and several from White River in Indiana.

35. **Lepiopomus anagallinus* Cope. RED-SPOTTED SUN-FISH. (M. V. 240.)

Salt River, Ky., where it is abundant. Not yet noticed from Illinois, although it doubtless occurs in the state.

36. *Lepiopomus pallidus* (Mit.) Gill & Jordan. BLUE SUN-FISH, COPPER-NOSED BREAM. (M. V. 241; *Ichthelis incisor* and *I. speciosus* Nelson, 37.)

The most abundant of the sun-fishes. Crystal Lake, Illinois River, Calumet R., L. Michigan, Wabash River, Quincy.

37. *Lepiopomus ischyrus* Jordan & Nelson. (M. V. 241; *Ichthelis aquilensis* Nelson, 37.)

The two original types of this species are all yet known—the one in the Illinois State Laboratory from Illinois River, the other in Mr. Nelson's collection from Calumet River. Renewed examination of the former specimen has convinced me of its distinctness from *L. pallidus*. The type specimen has palatine teeth, unlike *L. pallidus*. *Pomotis aquilensis* Girard is *Xenotis breviceps*, a Texas species.

Genus *XENOTIS*, Jordan.

38. *Xenotis megalotis* (Raf.) Jordan. Blue and Orange Sun-fish. (M. V. 242; *Ichthelis megalotis* and *I. sanguinolentus* Nelson, 38.)

Generally abundant. Illinois River; Clear Cr., in Union Co., Wabash R., Mackinaw Cr., Fox R.

39. **Xenotis aureolus* Jordan. Gilded Sun-fish. (M. V. 243; *Ichthelis macrochira* Nelson, 38.)

Probably abundant in small streams, but not certainly identified from the state.

40. **Xenotis lythrochloris* Jordan. Blue and Green Sun-fish. (M. V. 243.)

Abundant in small streams tributary to the Wabash in Indiana, but not yet recorded from Illinois.

41. *Xenotis inscriptus* (Agassiz) Jordan. Blue-green Sun-fish. (M. V. 243; *Ichthelis inscriptus* Nelson, 38.)

Moderately common in grassy ponds and streams in the southern part of the state. Wabash R., Cairo.

42. *Xenotis peltastes* (Cope) Jordan. (M. V. 243; *Ichthelis anagallinus* Nelson 38.)

Probably not very common. I have seen the specimen referred to by Mr. Nelson from Fox R.; and I have one or two more from the Wabash in Indiana.

Genus *EUPOMOTIS*, Gill & Jordan.

43. *Eupomotis aureus* (Wall.) Gill & Jordan. Common Sun-fish. Pumpkin Seed. (M. V. 244; *Pomotis auritus* Nelson, 38.)

Very common throughout the northern third of the state, its abundance and distribution being the same as of the Yellow Perch. Peoria, Crystal Lake, Ogle Co., Henry, Lake Michigan; Rock River.

44. *Eupomotis pallidus* (Ag.) Gill & Jordan. Pale Sun-fish. (M. V. 244.)

Probably not common. I have seen specimens from near St. Louis. The resemblance of this species to *Lepiopomus pallidus* is very strong.

Genus *COPELANDIA*, Jordan.

45. **Copelandia eriarcha* Jordan. (M. V. 246.)

As yet known only from streams near Milwaukee. It doubtless occurs in other tributaries of Lake Michigan.

Genus *CENTRARCHUS*, Cuvier.

46. *Centrarchus irideus* (Lac.) Cuv. et Val. SHINING BASS. (M. V. 246; Nelson, 37.)

Numerous specimens from the southern part of the state, referable to the southern *Centrarchus irideus*, but not typical specimens of that species, being in some respects intermediate between *C. irideus* and *C. macropterus*. Distinct as these two species appear, they may be found to intergrade so that they will have to be merged into one. In form of body and size of mouth these Illinois specimens are exactly *irideus*, but the ventral spine is more elongate, reaching the first anal spine, and the fins are rather higher than is usual in *irideus*. The dorsal fin in the young specimens has a large jet-black spot, strongly ocellated. The larger specimens examined have the dorsal plain. Union Co., Johnson Co.

Genus *POMOXYS*, Rafinesque.

47. *Pomoxys nigromaculatus* (Les.) Grd. GRASS BASS, CALICO BASS, BAR-FISH, BITTER-HEAD. (M. V. 247; *Pomoxys hexacanthus* Nelson, 37.)

Generally very abundant, especially in the northern part of the state. In the southern part of the state, the next species takes its place to a great extent. Peoria, Quincy, Chicago, Rock River, Henry.

48. *Pomoxys annularis* Raf. CROPPIE, NEW LIGHT, CAMPBELLITE, BACHELOR. (M. V. 247; Nelson, 37.)

Abundant everywhere in the tributaries of the Ohio and Mississippi, especially southward. Pekin, Peoria, Quincy; Wabash R., Ohio R., Mud-holes in bottoms, Johnson Co., Union Co., Mackinaw Cr.

Family ELASSOMATIDÆ, (the Elassomes.)

Genus *ELASSOMA*, Jordan.

49. *Elassoma zonatum* Jordan. (M. V. 248.)

A large number of specimens of this singular little fish were obtained by Prof. Forbes in ponds and sluggish waters in Union County. From these the anatomy of the species has beenpartly made out, and the affinities of the genus have probably been ascertained. As suspected by me when *Elassoma* was first discovered, its relations are with *Aphododerus*, and it will doubtless constitute a separate family, which should be placed next to the *Aphododeridæ*. The resemblance of both to the *Umbridæ* probably indicate real affinities. None of Professor Forbes' specimens are an inch in length. At the time of collection they were supposed to be the young of *Aphododerus*. In these specimens the black shoulder spot is feeble and there are three dark spots at the base of the caudal, vertically placed, imitating the black caudal bar in *Melanura*. The fin formula

is not exactly as originally counted in *Elassoma zonatum*. This last count is however correct, while the first, being made without the assistance of a microscope, may be erroneous. It is best to consider the Illinois, Arkansas and Texas specimens as identical, at least at present.

Fin formula. Dorsal IV, 10, rarely IV 9. Ventrals, I, 5, Anal III, 5, branchiostegals 5, vertebræ 28. Teeth in lower jaw stout, conical, slightly curved, their length about half the depth of the dentary bone; these teeth, for a part of the way at least, in 2 to 4 rows; similar teeth on the premaxillaries in 2 or 3 rows; no teeth on vomer or palatine or on pterygoids; lower pharyngeals narrow, apparently exactly as in *Aphododerus*, some what triangular, not united, with a few conic teeth, very sharp and slender; gill rakers small and short, tubercle-like; nostrils double, close together; opercular bones and preorbital not serrated. Scales cycloid; about eleven deep furrows on the imbedded part of each; concentric striæ strong. No lateral line. Vent normal.

The *Elassomatidæ* then differ from the *Aphododeridæ* in the position of the vent, in the dentition, (*Aphododeridæ* having teeth on the vomer, palatine and pterygoids,) in the number of ventral rays, and in the want of serratures to the preoperculum and preorbital, the edges of those bones being pectinated in the Pirate Perches.

Family APHODODERIDÆ, (the Pirate Perches.)

Genus *APHODODERUS*, Le Sueur.

50. *Aphododerus isolepis* (Nelson) Jordan. WESTERN PIRATE PERCH. (M. V. 249; *Sternotremia isolepis* Nelson, 39.)

This species is very closely related to the eastern *A. sayanus*, but apparently differs in the smaller scales and the presence of but three dorsal spines. The other has more frequently four spines, but often only three are developed. The scale formula of *A. isolepis* is subject to some variation. The following is the count of the number of scales in longitudinal series in ten specimens: 48, 48, 50, 50, 50, 51, 53, 53, 54, 55.

A study of the position of the vent in *A. isolepis* has developed some singular things. It becomes evident from the examination of a large series that the position of the vent is not a character of generic importance, as was supposed when the genus *Sternotremia* was proposed, nor is it apparently an individual or a sexual character as has been since suggested. The observations of Professor Forbes, verified by myself, appear to show that the position of the vent is dependent on the *age* of the fish. In the adult the vent is jugular, close behind the little projecting knob at the throat. In the youngest specimens examined, it is more or less behind the ventral fins. In specimens intermediate in size, its position is intermediate, the degree of advancement being proportionate to the size of the fish.

Occasional irregularities occur, but the above rule holds so generally that it can not be merely accidental. From it I infer that in the very young the position of the vent will be found to be as usual in Percoid fishes; as in the young flounder the eyes are symmetrical, but as the fish grows older, its aberrant characters become developed.

The following table shows the position of the vent in 26 specimens.

Length of Fish in Inches.	Position of Vent.
1	Opposite middle of ventrals.
1	same.
1	same.
1	same.
$1\frac{1}{4}$	" anterior two-fifths of ventrals.
$1\frac{1}{4}$	" anterior third "
$1\frac{1}{4}$	same.
$1\frac{1}{4}$	same.
$1\frac{1}{4}$	same.
$1\frac{1}{4}$	same.
$1\frac{1}{2}$	Opposite anterior fourth of ventrals.
$1\frac{1}{2}$	same.
$1\frac{1}{2}$	Opposite middle of ventrals.
$1\frac{3}{4}$	Just behind base of ventrals.
2	Between bases of ventrals (as in type of "*S. isolepis.*")
$2\frac{1}{4}$	Between bases of ventrals.
$2\frac{1}{4}$	same.
3	In front of ventrals, $\frac{3}{5}$ of the distances from base of ventrals to the throat "knob."
3	$\frac{4}{7}$ distance to "knob," (about as in types of "*A. mesotrema.*")
$3\frac{1}{4}$	$\frac{4}{7}$ distance from ventrals to "knob."
$3\frac{1}{2}$	$\frac{2}{5}$ distance to the "knob."
$3\frac{1}{2}$	$\frac{2}{3}$ distance to the "knob."
4	Half way from ventrals to "knob."
$4\frac{1}{4}$	$\frac{7}{9}$ distance to "knob," (as in "*A. cookianus*" and in *A. sayanus.*)
$4\frac{1}{4}$	$\frac{7}{9}$ distance to knob.
$4\frac{1}{4}$	$\frac{7}{8}$ distance to knob.

No other conclusion seems possible from the above except that the vent moves forward as the fish grows older, by the lengthening of the horizontal part of the intestine or "rectum" of the fish. *Sternotremia isolepis* is the young, *Sternotremia mesotrema* the half-grown and *Aphododerus cookianus* the adult of one and the same fish.

Aphododerus isolepis occurs in sluggish waters and bayous throughout the state. I have seen specimens from Calumet River, from numerous streams and sloughs in the southern part of the state and from the Wabash River at Mount Carmel,—the latter collected at different times by Robert Ridgway and Robert Kennicott. Union and Johnson counties.

Family SCIÆNIDÆ, (the Maigres.)

Genus *HAPLOIDONOTUS*, Rafinesqe.

51. *Haploidonotus grunniens* Raf. SHEEPSHEAD, CROAKER, GRUNTING PERCH, DRUM, WHITE PERCH. (M. V. 250. Nelson 40.)

Common in all the lakes and larger streams throughout the state. La Salle; Peoria.

Family COTTIDÆ, (the Sculpins.)

Genus *TRIGLOPSIS*, Girard.

52. *Triglopsis stimpsoni* Gill (Mss). DEEP WATER SCULPIN.

A species of this genus, which has received the above manuscript name, but which has never been described, occurs in the deeper waters of Lake Michigan.

Genus *URANIDEA*, Dekay.

53. *Uranidea kumlieni* Hoy. KUMLIEN'S BULL-HEAD. (M. V. 253; NELSON 41.)

Deep water in Lake Michigan.

54. *Uranidea hoyi* Putnam. (M. V. 253; Nelson 41.)

Deep water in Lake Michigan.

Genus *POTAMOCOTTUS*, Gill.

55. *Potamocottus alvordi* (Grd) Gill. ALVORD'S BULL-HEAD. (M. V. 254, *Pegedichthys alvordii*, Nelson 41.)

Rock River.

56. **Potamocottus wilsoni* (Grd) Gill. WILSON'S BULL HEAD. (M. V. 255.)

White River, Indiana, and probably also in Illinois—a doubtful species.

57. **Potamocottus meridionalis* (Grd) Gill. CAVE BULL-HEAD, GOBLIN, BLOB, MUFFLE-JAWS. (M. V. 254.)

Streams in the limestone region—often found in caves; abundant in Southern Indiana, but not yet recorded from Illinois.

Genus *TAURIDEA*, Jordan & Rice.

58. *Tauridea spilota* (Cope) Jordan & Rice. COW-FACED SCULPIN. (M. V. 255; *Cottopsis ricei* Nelson 40).

In deep water in Lake Michigan.

Suborder ANACANTHINI.

Family GADIDÆ (the Cod-fishes.)

Genus *LOTA*, Cuvier.

59. *Lota lacustris* (Walbaum) Gill. LING, BURBOT, LAWYER, EEL-POUT, CUSK. (M. V. 257, Nelson 42.)

Very abundant in Lake Michigan; stray specimens rarely taken in Illinois River, and in the Ohio and Mississippi. These probably have escaped through the canals.

Suborder HEMIBRANCHII.

Family GASTEROSTEIDÆ, (the Sticklebacks.)

Genus *EUCALIA*, Jordan.

60. *Eucalia inconstans* (Kirt.) Jordan. BLACK STICKLEBACK. (M. V. 259, Nelson 42.)

Abundant in small streams in the northern part of the state only. Rock R., Pecatonica R., tributaries of Lake Michigan; Crystal L., McHenry Co.

Genus *PYGOSTEUS*, Brevoort.

61. *Pygosteus occidentalis* (C. & V.) var. *nebulosus* (Ag.) Jor. MANY SPINED STICKLEBACK. (M. V. 260, Nelson 42.)

Lake Michigan—rather abundant in deep water.

Suborder PERCESOCES.

Family ATHERINIDÆ (the Silversides.)

Genus *LABIDESTHES*, Cope.

62. *Labidesthes sicculus* Cope. SILVERSIDES. (M. V. 261, Nelson 42.)

Generally abundant through the state, especially in ponds and bayous. Crystal L., McHenry Co ; Creeks, Peoria Co.; Rock R., Ogle Co.; Ill. R., Pekin ; Mackinaw Cr., McLean Co.

Suborder HAPLOMI.

Family CYPRINODONTIDÆ, (the Toothed Minnows.)

Genus *FUNDULUS*, Lacepede.

63. *Fundulus diaphanus* (L S.) Ag. BARRED KILLIFISH. (M. V. 263, Nelson 42.)

Very abundant in lakes and clear or sandy streams in the northern part of the state. In Lake Michigan it abounds about the sandy mouths of tributaries, keeping in schools in the shallow water near the edge. Calumet R.

64. *Fundulus menona* Jordan & Copeland. (M. V. 263.)
Rock River; Crystal Lake, McHenry Co.

Genus *ZYGONECTES*, Agassiz.

65. *Zygonectes notatus* (Raf.) Jor. Top Minnow. (M. V. 264, Nelson 42.)
Generally abundant in sluggish waters and canals, especially southward. Ill. R. at Pekin; Livingston Co.; Jackson Co.

66. *Zygonectes melanops* (Cope) Jordan. Black-eyed Top Minnow. (M. V. 264.)
Numerous specimens of this species were obtained by Professor Forbes in the streams and ponds of the southern part of the state. They agree exactly with Prof. Cope's description of his *Haplochilus melanops* from the Neuse River in North Carolina. The wide distribution of this species is rather unexpected. Cache R. and tributaries, Johnson Co.

67. *Zygonectus dispar* Agassiz. Striped Minnow. (M. V. 264, Nelson 42.)
Generally abundant in lakes, ponds and sluggish streams through the state, swimming in schools near the surface, slowly as if it were hard work. Specimens obtained by Prof. Forbes in the southern part of the state, are larger than any hitherto noticed, being more than two inches in length. Large specimens show a dark spot under the eye, somewhat as in the preceding species but fainter. Pekin; Beardstown; ponds and streams, Union and Johnson Counties.

Family UMBRIDÆ, (the Mud Minnows.)

Genus *MELANURA*, Agassiz.

68. *Melanura limi* (Kirtland) Ag. Mud Minnow, Mud Dace, Dog-fish. (M. V. 265, Nelson 43.)
Very abundant in ditches, muddy streams and prairie sloughs; found throughout the state, but much commonest northwards; numerous specimens from mud-holes in the bottoms of Johnson and Union Counties. Common in ditches near Crystal L., McHenry County.

Family ESOCIDÆ, (the Pikes.)

Genus *ESOX*, Linnæus.

69. *Esox nobilior* Thompson. Muskallunge. (M. V. 266, Nelson 43.)
In Lake Michigan and, according to Mr. Nelson, said to occur in some of the small lakes of the northern part of the state.

70. *Esox lucius* L. PIKE, GRASS PICKEREL. (M. V. 266; *E. lucius* var. *estor*, and *E. boreus*, Nelson 43.)

Very abundant in all large streams in the northern third of the state, its distribution being similar to that of *Perca*. Rock R., Ill. R.

71. *Esox salmoneus* Raf. LITTLE PICKEREL. (M. V. 267; *E. salmoneus* and *E. umbrosus* Nelson 43.)

Everywhere very abundant in ponds and bayous; especially common in ponds in Union Co.; also specimens from Fox R., and Ill. R. at Pekin.

72. *Esox cypho* Cope. HUMPBACK PICKEREL. (M. V. 267; Nelson 43.)

The specimen referred to by Mr. Nelson, from the Fox River at Geneva, is the only one which I have seen from the state.

[73. *Esox ravenelli*? Holbr.

A small, barred pickerel from Union Co., much more slender than *salmoneus*, with smaller scales, longer dorsal and anal fins, and different proportions generally, is perhaps referable to this species. It measures $2\frac{7}{8}$ inches to the caudal. Depth $7\frac{1}{3}$ in length, head $3\frac{1}{5}$, depth of head 10 and width of head 12. Eye $2\frac{3}{4}$ in nose (to tip of lower jaw) and $5\frac{3}{4}$ in whole head, its depth equal to the deeply grooved inter-orbital space. The middle of the head is at the front margin of the pupil.

The dorsal commences half its length in front of the anal. The paired fins are very short (V. $3\frac{1}{3}$ in head, P $4\frac{1}{2}$.) The pectorals are nearer ventrals than front of premaxillary, and the ventrals are midway between pectorals and anal.

Obscure vomerine teeth extend further back than the palatine bands.

The cheeks and opercles are wholly scaly. Lat. l. 125 scales, longitudinal rows 27, from dorsal to anal. D. 14 (complete rays), A. 14, V 10, Br. 14.

Color in alcohol dusky, with 12 yellowish, nearly vertical bands, plainest behind, narrow above, but widening below into triangular blotches, which merge in the pale color of the belly. A dark stripe extends from the tip of the nose to the hind edge of the opercle, and a vertical bar downward from the eye. The fins are all dusky. S. A. F.]

Family AMBLYOPSIDÆ, (the Blind Fishes.)

No species of Blind-fish has yet been recorded from Illinois.

Suborder ISOSPONDYLI.

Family PERCOPSIDÆ, (the Trout Perches.)

Genus *PERCOPSIS*, Agassiz.

74. *Percopsis guttatus* Ag. TROUT PERCH. (M. V. 270; Nelson 43.)

Very abundant in Lake Michigan, caught by the hundred by boys from the Chicago wharves. Occasionally found in the larger streams through the state.

Family SALMONIDÆ, (the Salmon.)

Genus *CRISTIVOMER*, Gill & Jordan.

75. *Cristivomer namaycush* (Walbaum) Gill & Jordan. GREAT LAKE TROUT, MACKINAW TROUT, LONGE, TOGUE. (M. V. 359; *Salmo namaycush* Nelson 44.)

Abundant in Lake Michigan.

Genus *COREGONUS*, Linnæus.

76. * *Coregonus tullibee* Rich. (M. V. 361.)

This strongly marked species occurs in Lake Superior, and it—or a closely related one, known as the "mongrel White Fish,"—is found in the eastern part of Lake Erie. (*Sterling—Milner.*) It has not yet been recorded from Lake Michigan.

77. *Coregonus nigripinnis* (Gill) Jor. BLUE FIN, BLACK FIN. (M. V. 362; *Argyrosomus nigripinnis* Nelson 44.)

Abundant in the deep water of Lake Michigan. Specimens may be obtained in any market in which lake fishes are sold.

78. *Coregonus artedi* Le Sueur. COMMON LAKE HERRING. (M. V. 362; *Argyrosomus clupeiformis* Nelson 44.)

Very abundant in Lake Michigan, and probably found in some of the small lakes in the northeastern part of the state.

79. *Coregonus hoyi* (Gill) Jor. MOON-EYED CISCO, CISCO OF LAKE MICHIGAN. (M. V. 362; *Argyrosomus hoyi* Nelson 44.)

Not rare, in the deeper waters of Lake Michigan, but not often seen in the fish markets.

80. *Coregonus clupeiformis* (Mitchill) Milner. COMMON WHITE FISH. (M. V. 362; *Coregonus albus* Nelson 44.)

Very abundant in Lake Michigan.

81. *Coregonus quadrilateralis* Rich. ROUND FISH, MENOMONEE WHITE FISH. (M. V. 362.)

This species is frequently taken in Lake Michigan.

Family HYODONTIDÆ, (the Moon-eyes.)

Genus *HYODON*, Le Sueur.

82. *Hyodon tergisus* Le Sueur. COMMON MOON-EYE, TOOTHED HERRING. (M V. 277; Nelson 44.)

Very common throughout the state in all large bodies of water. Cairo, Peoria.

Family DOROSOMATIDÆ, (the Gizzard Shad.)

Genus *DOROSOMA*, Rafinesque.

83. *Dorosoma cepedianum* (Le S.) var. *heterurum* (Raf.) Jor. GIZZARD SHAD, HICKORY SHAD. (M. V. 279 ; *Dorosoma notatum* Nelson 44.)

Abundant in all the larger streams, and escaped through the canals into Lake Michigan. Ohio R. at Cairo, Ill. R. at La Salle, Pekin and Peoria.

Family CLUPEIDÆ, (the Herrings.)

Genus *POMOLOBUS*, Rafinesque.

84. *Pomolobus chrysochloris* Raf. SKIP JACK, OHIO SHAD. (M. V. 279 ; Nelson 44.)

Found in all the larger streams and escaped into Lake Michigan. Cairo, Henry.

Genus *ALOSA*, Cuvier.

85. *Alosa sapidissima* (Wilson) Storer. COMMON SHAD. (M. V. 278 ; Nelson 44.)

Introduced into some streams.

Suborder EVENTOGNATHI.

Family CYPRINIDÆ.

Genus *CAMPOSTOMA*, Agassiz.

86. *Campostoma anomalum* (Raf.) Ag. STONE LUGGER. (M. V. 288, Nelson 44.)

Everywhere very abundant, ascending every small brook in the spring. Vermilion R., La Salle Co.; Rock R, Ogle Co. and Pine Cr., Union Co.

Genus *PIMEPHALES*, Rafinesque.

87. *Pimephales promelas* Raf. FAT-HEAD, BLACK-HEAD. (M. V. 288 ; *P. promelas* and *P. milesii* Nelson 45.)

Found throughout the state, but probably not generally abundant. Bailey's Cr., La Salle Co.; Rock R., Ogle Co.

Genus *HYBORHYNCHUS*, Agassiz.

88. *Hyborhynchus notatus* (Raf.) Ag. BLUNT-NOSED MINNOW. (M. V. 288 ; Nelson 45.)

Generally abundant, especially in the northern part of the state. Southward its place is taken by the next, if the two be really distinct. Mackinaw Cr., Woodford Co.; McLean Co.; Rock R., at Oregon; Little Wabash, Effingham ; Ill. R., Peoria ; Crystal L., Kane Co.

89. *Hyborhynchus superciliosus* Cope. (M. V. 289.)

Very abundant in the bottoms of Johnson and Union counties, and in the southern part of the state generally. It is very close to the preceding, and may not be really different. Cache R. and Clear Cr., Union Co.; Rock R., Ogle Co.

Genus *HYBOGNATHUS*, Agassiz.

90. *Hybognathus argyritis* Grd. SILVERY MINNOW. (M. V. 289; Nelson 45.)

Abundant in the southern third of the state. Bottoms of Johnson and Union counties; Wabash River; Ohio River; Peoria.

91. *Hybognathus nuchalis* Agassiz. BLUNT-JAWED MINNOW. (M. V. 289; Nelson 45.)

Wabash R. "A few specimens in the state collection from central Illinois." (Nelson.) The distinctions between this species and the preceding do not appear to be very clear. Normal, Pekin.

Genus *ALBURNOPS*, Girard.

(*Hybopsis* Cope, not of Ag.)

92. *Alburnops storerianus* (Kirt.) Jor. STORER'S MINNOW. (M. V. 290; Nelson 46.)

Rather frequent in Lake Michigan and in the small lakes of northern Indiana. Peoria, Chicago.

93. *Alburnops hudsonius* (Clint) Jor. SPAWN EATER. (M. V. 290; Nelson 46.) L. Mich., Ill. R.

94. **Alburnops tuditanus* Cope. (M. V. 290; Nelson 46.)

Found by Prof. Cope in various tributaries of Lake Michigan and of the Wabash in Indiana. The species is unknown to me.

[95. *Alburnops nubilus* Forbes, n. s.

Twenty specimens from Rock R., in Ogle Co., approaching *H. spectrunculus*, are not referable to any species or description of the group *Alburnops*, (M. V., *Hybopsis* Jordan & Copeland's Check-list) to which they undoubtedly belong.

The mouth is inferior and horizontal; the teeth are in one row, 4–4, but slightly hooked, with large masticatory surface, and the dorsal is over the ventrals.

The length is 2¼ inches to the caudal. Depth 3¾ to 4 in length, head 4½, eye 3 in head, nose 3¾, interorbital space 3 to 3½. The depth of the head is contained 6½ to 7 times in the head and body.

D I–8, A I–9. Scales 5–37–3, 14 before D. The lateral line is deflexed on the anterior fourth. The deep body, narrow head and large eye,

are the conspicuous characters. The color is unusually dusky, a broad dark lateral band extends forward over the opercle through the eye to the tip of the nose. There is no caudal spot, and all the fins are plain. S. A. F.]

96. *Alburnops stramineus* Cope. STRAW-COLORED MINNOW. (M. V. 291; Nelson 46.)

Probably common in the southern two-thirds of the state. The only specimens noticed by me were from McLean, Crawford and Union Counties.

97. *Alburnops microstomus* (Raf.) Jor. (M. V. 291.)

Specimens apparently of this species, from Clear Creek, in Union County. It occurs in the streams of Kentucky.

98. *Alburnops volucellus* Cope. (M. V. 291; Nelson 46.)

Specimens collected by Professor Copeland in the Rock and Pecatonica Rivers.

99. *Alburnops fretensis* Cope. (M. V. 292; Nelson 47.)

Specimens are in the collection from Rock River, and from McLean Co. Pine Cr. and Rock R., Ogle Co.; Henry, Normal.

100. *Alburnops hæmaturus* Cope. (M. V. 292; Nelson 47.)

Several specimens are in the collection from the Illinois River at Peoria.

Genus *LUXILUS*, Rafinesque.

101. *Luxilus cornutus* (Raf.) Jor. SHINER. (M. V. 293; Nelson 47.)

The commonest fish in the state, occurring by thousands in every stream. Mackinaw Cr., McLean Co.; Rock R., Ogle Co.; Pine Cr.; Ill. R., Pekin; Effingham; Cache R., Union Co.; Johnson Co.; Crystal L., Kane Co.

Genus *PHOTOGENIS*, Cope.

102. *Photogenis analostanus* (Grd.) Jor. SILVER FIN. (M. V. 294; *Cyprinella analostana* Nelson in Errata; *Cyprinella galactura* Nelson 47.)

Everywhere abundant, perhaps most so in the valley of the Wabash. McLean Co.; very common in Rock R., Ogle Co.; Effingham; Peoria; Union Co.

Genus *CYPRINELLA*, Girard.

103. *Cyprinella forbesi* Jordan (sp. nov.) FORBES' RED FIN.

A small deep, strongly compressed species, belonging to the group called by Girard *Moniana*, and related to the species called *complanata*, *gibbosa*, etc. Body oblong, elevated, strongly compressed, the depth great-

est just in front of the dorsal fin, contained 3 times in the length to base of caudal; caudal peduncle moderately slender. Head rather stout and deep, $3\frac{2}{3}$ in length of body; its upper outline depressed, the nape elevated, so that the profile is somewhat concave; thickness of head through the cheeks, greater than the thickness of the body. Mouth tolerably large, quite oblique, the lower jaw slightly included. Eye not large, its length about 4 in head.

Scales, as usual in the genus, closely imbricated. Lateral line strongly decurved, with 35 scales in its course, six rows above it, and about two below. Thirteen scales in front of the dorsal.

Dorsal fin inserted just behind beginning of ventrals, about half higher than long, its rays I–7; anal fin somewhat elevated in front, its rays I–8; its anterior rays rather longer than the base of the fin. Caudal fin moderate, widely forked. Pectorals barely reaching the ventrals; ventrals barely reaching anal.

Teeth 4-4, hooked, sharp-edged, the edges of the teeth somewhat crenate.

Head and ante-dorsal region in the male fish covered with rather small white prickles, larger than in the genus *Lythrurus*; caudal peduncle covered below the lateral line with similar tubercles. Chin with a few prickles.

Colors, in spirits bluish above, pale below, a vague dark shoulder blotch; upper part of dorsal dusky; lower part of anal and ventrals somewhat milky.

In life the colors are as follows, according to Professor Forbes: General color steel-blue with a reddish tinge, a crescent shaped mark of a violet blue color behind the shoulders, followed by a crimson crescent; belly orange red; anal and caudal blood red.

Length of adult $2\frac{3}{4}$ inches.

Many specimens obtained by Professor Forbes in clear streams of southern Illinois, a few from mud-holes on the bottoms.

This species resembles the figures given of *Moniana complanata* and *M. gibbosa* Girard, but the known inaccuracy of those figures and the utterly slovenly character of the accompanying descriptions, prevents any attempt at the identification of our specimens with them. Girard's specimens were from the Rio Grande, and "on general principles" are probably different. Those interested in knowing the character of Dr. Girard's work on the smaller *Cyprinidæ* cannot do better than to read his description of *Moniana rutila* and *Moniana gracilis* and then, as suggested by Dr. Gunther, to compare the figure of *Moniana frigida* given in the Pacific R. R. Surveys, (1858) with that of the same species drawn by the same artist in the Mexican Boundary Survey (1859.) All the fishes drawn by this artist at one "sitting," are cast in the same mould regardless of the appearance of the fish from which they were drawn.

Most of the types of Girard's *Cyprinellæ* are lost. The others can only be identified almost at random by future students of Texan ichthyology.

Since writing the above, I have examined specimens of *Moniana complanata* Grd. (*Moniana gibbosa* Grd.) from the Rio Grande, *C. forbesi*, though closely related is unquestionably distinct, the form of the profile being notably different.

Genus *LYTHRURUS*, Jordan.

104. *Lythrurus atripes* Jordan. (sp. nov.) COMPRESSED RED-FIN.

Body moderately elongate, very strongly compressed and elevated, the greatest depth about $3\frac{1}{3}$ in length; head comparatively pointed; somewhat depressed above, so that an angle is formed at the occiput; length of head about $3\frac{3}{4}$ in that of body; mouth rather large, quite oblique, the maxillary reaching about to the front of the eye; the lower jaw slightly projecting beyond the upper; eye small, smaller than in the other *Lythruri*, 4 in head, rather shorter than the snout.

Scales of the usual type in the genus, very closely imbricated, their exposed surfaces notably higher than long, especially anteriorly. Lateral line very strongly decurved; scales 8–44–3. Dorsal fin beginning about midway between ventrals and anal, rather high anteriorly, its rays I–7, anal rays I–11. Pectorals not quite reaching ventrals, the latter just to vent.

Color in spirits dusky bluish or livid, much as in *L. cyanocephalus*; no traces of the vertical bars sometimes noticed in *L. diplæmius*, each scale with many fine black punctulations. Coloration of fins peculiar, the usual dusky spot at the base of the dorsal in front, this spot smaller than in the other species, a black transverse bar across the upper part of the dorsal; anal similarly colored to the dorsal, the markings paler. In *L. diplæmius* the anal fin is plain. Tips of ventrals dusky, belly and lower fins probably crimson in males in the spring; male specimens profusely covered on head, front of back, sides of body anteriorly, and on lower jaw with small white tubercles as in the other species of the genus.

Length of types $2\frac{1}{2}$ to 3 inches. Collected by Prof. Forbes in various streams in Union and Johnson counties.

The four species now known of this genus, *atripes*, *cyanocephalus*, *diplæmius* and *ardens*, are closely related, but may be readily distinguished when compared. *Ardens* is most elongate and looks somewhat like a *Notropis; cyanocephalus*, small and short, resembles *Pimephales*; *atripes* has the smallest eye and the most compressed body. The coloration of the lower fins will probably always distinguish it.

105. *Lythrurus diplæmius* (Rafinesque) Jordan. RED FIN. (M. V. 295; Nelson 47.)

Abundant in the southern two-thirds of the state, especially in tributaries of the Wabash and the Ohio. Mackinaw Cr., McLean Co.; Normal; Effingham; Union Co; Rock R., Ogle Co.; Peoria.

[var. *gracilis* Forbes.

Length $2\frac{1}{2}$ to 3 in, depth $4\frac{3}{4}$ in length, head $4\frac{1}{2}$, eye $3\frac{1}{3}$ in head, nose 3, D, I-8, A, I-10. Scales 8-48-4. Dorsal and anal fins marked as in *atripes*. Several specimens from Rock R., Ogle Co. S. A. F.]

106. **Lythrurus cyanocephalus* Copeland. HOY'S RED FISH. (M. V. 295; Nelson 47.)

Professor Copeland's types were from Root River at Racine. Others have been taken in tributaries of Rock R. near Beloit, within a few miles of the state line.

Genus *NOTROPIS*, Rafinesque.

107. *Notropis rubrifrons* (Cope.) Jordan. ROSY FACED MINNOW. (M. V. 296; *Minnilus rubrifrons* Nelson 47.)

Abundant in the Ohio and Wabash vallies. I have examined specimens from Rock River, and Mr. Nelson gives it from tributaries of the Illinois. Oregon; Ill. R.

108. *Notropis atherinoides* Raf. EMERALD MINNOW. (*Notropis rubellus*, *dinemus* and *dilectus* M. V. 296; *Minnilus dilectus*, *amabilis*, *rubellus* and *dinemus* Nelson 46, 47.)

Everywhere very abundant, caught by the thousand for bait off the wharves at Chicago. The species termed *dinemus*, *rubellus*, *jaculus*, *arge*, *dilectus*, and *amabilis*, seem to shade into one another in the most exasperating way, and until some permanent character is shown, I propose to drop the farce of considering them as distinct, and to adopt for all the oldest specific name applied to one of the type, viz: *atherinoides* Raf. The species as thus defined, is a very variable one, but not more so than *Luxilus cornutus*, *Semotillus corporalis*, *Campostoma anomalum* or *Ceratichthys biguttatus*, all species of similarly wide distribution. Normal, Geneva, Pine Cr., Chicago, Henry, Union Co., Peoria, Oregon, Ill.

Genus *EPISEMA*, Cope & Jordan.

109. **Episema ariomma* (Cope) Jor. BIG-EYED SHINER. (*Cliola ariomma* M. V. 298.)

White River, Indiana, abundant in still places in the river; not yet recognized elsewhere, though doubtless occurring in Illinois.

110. **Episema scabriceps* Cope. ROUGH-HEADED SHINER. (*Cliola scabriceps* M. V. 298; *Photogenis scabriceps* Nelson 47.)

White River; not yet noticed in Illinois.

[111. *Episema jejuna* Forbes, n. s.

A number of specimens, from the Ill. R., of a pale fish of rather slender and graceful form have been assigned to this genus with some doubt. The irregularly beveled face of the pharyngeal teeth simulates a masticatory surface, although the extreme edge is more or less crenate. The teeth are distinctly hooked, 1 or 2, 4-4, 1 or 2, (in one case, apparently abnormal, 5, 2.) The dorsal begins a little before the ventrals; the mouth is large and oblique, the upper jaw (from middle of front margin to tip of maxillary) being contained 3 times in the head.

The total length of my largest specimens is 3 inches. Depth $4\frac{2}{3}$ in length to caudal, head 4; eye $3\frac{2}{3}$ in head, equal to nose, interorbital space $2\frac{2}{3}$ in head; depth of head in length to caudal 6 or 7 times.

The scales are 5-37-3, with 15 or 16 before the dorsal. The lateral line is decurved on the anterior fifth.

D. I-8, $\frac{2}{3}$ as long as high, anterior rays nearly or quite 3 times as long as posterior. The front of the fin is about equidistant from nose and middle of base of caudal. The anal has 1 spine and 7 soft rays, and is about $\frac{2}{3}$ as long as high.

The caudal is deeply forked. The head is nearly flat above, the nose blunt and regularly rounded.

Color in alcohol pale, with a broad silvery band overlying a plumbeous shade on sides. The dorsal is sometimes clouded with minute black specks, and the belly (usually colorless) is occasionally rosy-tinted. S. A. F.]

This species and the two preceding belong to a group termed *Episema* by Cope and Jordan, and distinguished from *Cliola* proper by the usual presence of teeth 2, 4–4, 2, instead of 4–4. *Episema* should probably be restored to generic rank. D. S. J.

Genus *ERICYMBA*, Cope.

112. *Ericymba buccata* Cope. SILVER-MOUTHED DACE. (M. V. 299; Nelson 45.)

Very abundant in White River and other tributaries of the Wabash, with sandy or gravelly bottoms. Several specimens from the Little Wabash, at Effingham.

Genus *PHENACOBIUS*, Cope.

113. *Phenacobius scopiferus* (Cope) Jordan. (M. V. 299; *Phenacobius teretulus* var. *liosternus* Nelson 46.)

Small streams in McLean Co.

Genus *GILA*, Baird & Girard.

114. *Gila elongata* (Kirt) Jordan. RED-SIDED MINNOW. (M. V. 300; Nelson 47.)

Northern part of the state chiefly. Rock River, Lake Michigan.

Genus *NOTEMIGONUS*, Rafinesque.

115. *Notemigonus chrysoleucus* (Mitch.) Jor. SHINER, BREAM. (M. V. 301; *Notemigonus americanus* Nelson 48.)

Everywhere very abundant in ponds and bayous. The most tenacious of life of the Minnows. Pekin, Normal, Effingham, Henry, Union Co., Ogle Co.

Genus *CHROSOMUS*, Rafinesque.

116. *Chrosomus erythrogaster* Rafinesque. RED-BELLIED DACE. (M. V. 302; Nelson 47.)

Abundant in all small clear streams, especially in the northern part of the state. Normal; Vermilion R., La Salle Co.; Rock R., Ogle Co.

Genus *PHOXINUS*, Rafinesque.

117. *Phoxinus neogæus* Cope. NEW WORLD MINNOW. (M. V. 302· Nelson 47.)

"A single specimen obtained in the Fox River at Geneva" (*Nelson.*) Specimens also from Wisconsin River.

Genus *HEMITREMIA*, Cope.

118. *Hemitremia heterodon* Cope. (M. V. 303; Nelson 47.)

Abundant in northern Illinois and Wisconsin. Lake Michigan; Calumet R.; Fox R.; Rock R.; Bailey's Cr., La Salle Co. This species has the teeth 4–4 and should probably be referred to *Alburnops.*

Genus *SEMOTILUS*, Rafinesque.

119. *Semotilus corporalis* (Mitch.) Putnam. CHUB, CREEK CHUB, HORNED DACE. (M. V. 304; Nelson 45.)

Everywhere very abundant, frequenting small creeks, commonest of fishes. McLean Co.; Ogle Co.; Jackson Co.; Pekin; Effingham; Union Co.

Genus *CERATICHTHYS*, Baird.

120. *Ceratichthys biguttatus* (Kirt.) Girard. HORNED CHUB, HORNY-HEAD, RIVER CHUB. (M. V. 305; Nelson 45.)

Everywhere very abundant, frequenting the river channels more than the preceding species. Rock R., Ogle Co.

121. *Ceratichthys amblops* (Raf.) Girard. BIG-EYED CHUB. (M. V. 306.)

Abundant in the Wabash valley.

122. *Ceratichthys dissimilis* (Kirt.) Cope. SPOTTED SHINER (M. V. 306; Nelson 45.)

In tributaries of the Wabash and Illinois, frequenting the river channels. Probably abundant. Rock R., Ogle Co.

Genus *COUESIUS*, Jor., Mss.

123. *Couesius prosthemius* Cope. LAKE CHUB. (M. V. 307.)

In Lake Michigan. Specimens in the National Museum from near Evanston.

Genus *RHINICHTHYS*, Agassiz.

124. *Rhinichthys cataractæ* (C. & V.) Jor. LONG-NOSED DACE. (M. V. 307; *Rhinichthys nasutus* and *R. maxillosus* Nelson 45.)

In clear tributaries of Lake Michigan. Chicago.

125. *Rhinichthys obtusus* Agassiz. Brown-nosed Dace. (M. V. 308; *Rhinichthys atronasus* and *R. lunatus* Nelson 45-46.)

Found throughout the state in clear streams and "spring runs." The distinctions between this species and the eastern *R. atronasus* do not seem to be very important. Oregon, Ill.

126. *Rhinichthys meleagris* Agassiz. (M. V. 308; Nelson 46.)

Streams of central and western Illinois. Vermilion River, Bai-Creek, La Salle Co.; McLean Co. Prof. Agassiz's types were from the Mississippi River.

Genus *CARASSIUS*, Nilsson.

127. *Carassius auratus* (L.) Bleeker. Gold-fish. (M. V. 308; Nelson 48.)

Naturalized in some streams. Pecatonica R., Freeport.

Family CATOSTOMIDÆ, (the Suckers.)

Genus *PLACOPHARYNX*, Cope.

128. *Placopharynx carinatns* Cope. (M. V. 311; Nelson 49.)

I have two young specimens of this species from Illinois River, and a pair of the stout pharyngeal bones from the Wabash River at Terra Haute. It is said by fishermen to be rather common in the Wabash River.

Genus *MYXOSTOMA*, Rafinesque.

129. *Myxostoma carpio* (Cuv. & Val.) Jordan. White Lake Mullet. (M. V. 312; *Teretulus carpio* Nelson 49.)

In Lake Michigan, and the larger rivers. Probably not very common.

130. *Myxostoma macrolepidotum* (Le S.) Jordan. Common Mullet. (M. V. 313; *Teretulus macrolepidotum* Nelson 49.)

Lake Michigan, etc. Ill. R. at La Salle, Rock R.

Var. duquesnii (Le S.) Jor. Common Red Horse, Mullet, White Sucker. (M. V. 313; *Teretulus duquesnii* Nelson 49).

Everywhere very abundant, ascending all the streams in the spring. Rock R , Ogle Co.; Pekin; Cache R., Union Co.; Mackinaw Cr.; Little Wabash.

131. *Myxostoma aureolum* (Le S.) Jor. Small-headed Mullet, Golden Red Horse. (M. V. 314; *Teretulus aureolus* Nelson 49.)

Abundant throughout the state in the larger bodies of water, especially northward. Pekin, Peoria.

132. **Myxostoma anisurum* (Raf.) Jor. LONG-TAILED SUCKER. (M. V. 315.)

Abundant in Ohio River near Cincinnati; not yet noticed in Illinois.

133. *Myxostoma velatum* (Cope) Jor. SMALL-MOUTHED RED HORSE, WHITE NOSE. (M. V. 317; *Teretulus anisurus* and *T. velatus* Nelson 49.)

Generally abundant in the larger streams.

Genus *MINYTREMA*, Jordan.

134. *Minytrema melanops* (Raf.) Jor. SPOTTED SUCKER. (M. V. 318; *Erimyzon melanops* Nelson 48.)

Generally abundant, especially southward.

Genus *ERIMYZON*, Jordan.

135. *Erimyzon sucetta* (Lac.) Jord. CHUB-SUCKER, CREEK-FISH. (M. V. 319; *Erimyzon oblongus* Nelson 48.)

Everywhere very abundant, ascending small streams in spring. Union Co., Johnson Co.

Genus *CATOSTOMUS*, Le Sueur.

136. *Catostomus nigricans* Le S. STONE-ROLLER, HOG SUCKER, CRAWL-A-BOTTOM, HAMMER-HEAD. (M. V. 319; Nelson 48.)

Everywhere common, frequenting rapids and shallows in clear streams. Rock R., Ogle Co.; Mackinaw Cr.

137. *Catostomus commersonii* (Lac.) Jor. COMMON SUCKER, WHITE SUCKER. (M. V. 320; *Catostomus teres* Nelson 48.)

Everywhere very abundant. Ill. R., Mackinaw Cr., Pine Cr.; Cache R., Union Co.; Rock R.

138. *Catostomus longirostrum* Le Sueur. RED-SIDED SUCKER, LONG-NOSED SUCKER. (M. V. 320; *Catostomus hudsonius* Nelson 48.)

Abundant in Lake Michigan.

Genus *CYCLEPTUS*, Rafinesque.

139. *Cycleptus elongatus* (Le S.) Ag. GOURD-SEED SUCKER, BLACK-HORSE, MISSOURI SUCKER. (M. V. 320; Nelson 50.)

In the Ohio and Mississippi Rivers, and all their larger tributaries; not generally common, but often seined in large numbers. Peoria, Ill.

Genus *CARPIODES*, Rafinesque.

140. *Carpiodes velifer* (Raf.) Ag. SPEAR-FISH, SAIL-FISH, SKIM-BACK, QUILL-BACK. (M. V. 321; *Ichthyobus velifer* Nelson 49.)

Generally common in the larger streams. Peoria.

141. *Carpiodes selene* Cope. MOON CARP-SUCKER. (M. V. 321.)

Abundant in Lake Michigan. The distinctions between this species and the next do not seem to be very important.

142. *Carpiodes cutisanserinus* Cope. LONG-FINNED CARP-SUCKER. (M. V. 321.)

Generally abundant in the larger tributaries of the Ohio. Rock R., at Oregon, Ill.

143. *Carpiodes difformis* Cope. DEFORMED CARP-SUCKER. (M. V. 321; *Ichthyobus difformis* Nelson 49.)

Numerous specimens in the collection from Illinois River. Professor Cope's types came from the Wabash. Henry, Ill.

144. *Carpiodes bison* Agassiz. BUFFALO CARP-SUCKER. (M. V. 322; *Ichthyobus bison* 49.)

"Found in the larger rivers." (Nelson.)

145. *Carpiodes cyprinus* (Le S.) Ag. SILVERY CARP-SUCKER. (M. V. 322.)

Specimens apparently identical with this eastern species are in the state collection from Illinois River. Henry, Ill.

146. *Carpiodes thompsoni* Agassiz. LAKE CARP-SUCKER. (M. V. 322; *Ichthyobus thompsoni* Nelson 49.)

The specimens from Lake Michigan noticed by Mr. Nelson, are in the collection. Henry, Ill.

147. *Carpiodes carpio* (Raf.) Jordan. RIVER CARP-SUCKER. (M. V. 322; *Ichthyobus carpio* Nelson 49.)

Specimens from Wabash River and from the Ohio at Cairo.

Genus *ICHTHYOBUS*, Raf.

148. *Ichthyobus bubalus* (Raf.) Ag. BROWN BUFFALO, RED MOUTH. (M. V. 322; Nelson 49.)

Specimens examined from Wabash River and from the Illinois at Peoria, where it is the most abundant buffalo fish. Peoria, Henry, and McLean Co.

Genus *BUBALICHTHYS*, Agassiz.

149. *Bubalichthys urus* Ag. BLACK BUFFALO, BIG-MOUTHED BUFFALO. (*Bubalichthys niger* M. V. 323; Nelson 50.)

Mississippi River at Quincy. Probably generally abundant in the larger streams. Peoria.

150. *Bubalichthys cyanellus* (Nelson) Jordan. SMALL-MOUTHED BUFFALO. (*Bubalichthys bubalinus* and *Bubalichthys altus*. M. V. 325; *Ichthyobus cyanellus* Nelson 49.)

Abundant in all the larger streams throughout the state. An examination of Mr. Nelson's typical specimens shows that they are the young of the common *Bubalichthys bubalus* of Agassiz. As the specific name "*bubalus*" is hardly tenable for this species, if we conceive that the *bubalus* of Rafinesque is an *Ichthyobus*, I have lately suggested the name *bubalinus* as a substitute. *Cyanellus* has however priority over *bubalinus*. I therefore propose to adopt Mr. Nelson's name for this species.

Order NEMATOGNATHI.

Family SILURIDÆ, (the Cat-fishes.)

Genus *ICHTHÆLURUS*, Rafinesque.

151. **Ichthælurus furcatus* (C. & V.) Gill. FORK-TAILED CAT. (M. V. 328.)

Ohio and Mississippi rivers; probably not common. I have seen none from within the limits of the state.

152. *Ichthælurus robustus* Jordan. CHUCKLE-HEADED CAT. (M. V. 328; *Ictalurus furcatus* Nelson 50.)

Illinois River; probably not rare in the larger streams. Peoria.

153. *Ichthælurus punctatus* (Raf.) Jordan. COMMON CHANNEL CAT, BLUE CAT, WHITE CAT. (M. V. 328; Nelson 50.)

Very abundant in all the large streams throughout the state. Cairo; Pekin; Rock R., Ogle Co.; Bottoms, Union Co.

Genus *AMIURUS*, Rafinesque.

154. *Amiurus nigricans* (Le S.) Gill. GREAT FORK-TAILED CAT, GREAT MISSISSIPPI CAT, GREAT LAKE CAT-FISH. (M. V. 329.)

Abundant in the Mississippi and Ohio rivers and in Lake Michigan. This species reaches an immense size and is probably the largest of all our fresh water fishes.

155. *Amiurus natalis* (Le S.) Gill. YELLOW CAT. (M. V. 331; *Amiurus cupreus* Nelson 50.)

Everywhere more or less abundant in ponds and bayous. McLean Co.; Cache R., Johnson Co.

156. *Amiurus vulgaris* (Thompson) Nelson. LONG-JAWED CAT. (M. V. 331; Nelson 50.)

Abundant in the Mississippi River at St. Louis, and in Lake Michigan. Pekin, Ill.

157. *Amiurus catus* (L.) Gill. BULL-HEAD. (M. V. 332; *Amiurus atrarius* Nelson 332.)

Great Lakes and their tributaries. Vermilion R.; Ill. R.; McLean Co.

158. *Amiurus marmoratus* (Holbrook) Jordan. MARBLED CAT. (M. V. 332.)

Numerous specimens of a cat-fish, marbled in color, and not evidently distinguishable from *A. marmoratus*, Holbrook, were collected by Professor Forbes in southern Illinois, and one or two from Illinois River. Considerable variation is shown in the coloration, some being nearly plain, others much variegated. In one specimen, the broad head with depressed front much resembles that of *A. xanthocephalus*. In all the adipose fin is very large and the dorsal spine is quite high. Henry, Ill., Johnson Co.

159. *Amiurus melas* (Raf.) Jordan & Copeland. BLACK CAT. (M. V. 332; *A. confinis* and *A. pullus* Nelson 50.)

Abundant in the streams of the southern half of the state. McLean Co., Union and Johnson Co's., (Clear Cr., Bottoms, Cache R.)

160. *Amiurus xanthocephalus* (Raf.) Gill. YELLOW-HEADED CAT. (M. V. 333; *A. albidus* Nelson 50.)

Common in the southern part of the state. This is not "our commonest cat-fish" as stated by Mr. Nelson. [The specimens upon which Mr. Nelson based this statement were labeled *nebulosus* in the collection (given as a synonym of *albidus* in M. V., first edition,) but have been identified with *catus* by Dr. Jordan. S. A. F.] Peoria.

Genus *PELODICHTHYS*, Rafinesque.

161. *Pelodichthys olivaris* (Rafinesque) Gill & Jordan. MUD CAT. (M. V. 334; *Hopladelus olivaris* Nelson 50.)

Common in the larger streams, reaching a large size. Peoria.

Genus *NOTURUS*, Rafinesque.

162. *Noturus flavus* Rafinesque. YELLOW STONE CAT. (M. V. 335; Nelson 50.)

Rather common, especially southward and in the larger streams.

163. *Noturus exilis* Nelson. SLENDER STONE CAT. (M. V. 335; Nelson 51.)

Besides Mr. Nelson's types, which were from McLean Co., I have obtained specimens from Root R., Wis., and from Kansas.

164. *Noturus miurus* Jordan. Saw-spined Stone Cat. (M. V. 336; *Noturus marginatus* Nelson 50.)

Abundant, especially southward. Specimens from the Wabash and from the Cache R., in Johnson Co.

165. *Noturus sialis* Jordan. Chubby Stone Cat. (M. V. 337.)

Generally abundant, with the preceding. Also Ill. R. at Pekin, Cairo, Ill.

Order APODES.

Family ANGUILLIDÆ, (the Eels.)

Genus *ANGUILLA*, Thunberg.

166. *Anguilla rostrata* (Le S.) D K. Common Eel. (M. V. 338; Nelson 51.)

Occasionally taken in most of the waters of the state, but not common. It is probably not indigenous in the upper lakes, having been introduced, or else having escaped through the canals from the Ohio, or probably both. Ill. R. at Peoria.

Sub-class GANOIDEI.

Order CYCLOGANOIDEI.

Family AMIIDÆ, (the Bow-fins.)

Genus *AMIA*, Linnæus.

167. *Amia calva* Linnæus. Dog-fish, Mud-fish, Bow-fin. (M. V. 340; Nelson 51.)

Abundant throughout the state in the lakes and *larger* streams. In the small streams it is seldom found. [Common in ponds in S. Ill., where it is generally eaten, and is known as the "Grinnel," (Gunnel ?). S. A. F.] Ponds S. Ill., Ill. R., Ohio R., Miss. R.

Order RHOMBOGANOIDEI.

Family LEPIDOSTEIDÆ, (the Gar-Pikes.)

Genus *LEPIDOSTEUS*, Lacepede,

168. *Lepidosteus osseus* (L.) Ag. Gar Pike. (M. V. 342; Nelson 51.)

Abundant in the larger streams throughout the state. Illinois and Ohio rivers.

169. *Lepidosteus platystomus* Raf. SHORT-NOSED GAR. (M. V. 342; Nelson 51.)

Occurs throughout the state in the larger streams. It is much more abundant in tributaries of the Mississippi than in the Lake. The commonest gar in the Ill. R. Peoria, Pekin.

Genus *LITHOLEPIS*, Rafinesque.

170. *Litholepis spatula* (Lac.) Jor. ALLIGATOR GAR. (M. V. 342; *Litholepis adamantinus* Nelson 51.)

In the Mississippi and Ohio, not common, "occasionally straying up smaller rivers into the interior of the state." (Nelson.)

Order SELACHOSTOMI.

Family POLYODONTIDÆ, (the Spoonbills.)

Genus *POLYODON*, Lacepede.

171. *Polyodon folium* Lacepede. PADDLE-FISH, DUCK-BILL, SPOON-BILL. (M. V. 344; Nelson 51.)

Common in all the larger streams, especially southward. Ohio R. at Cairo; Ill. R. at Pekin, Peoria, &c.

Order CHONDROSTEI.

Family ACIPENSERIDÆ, (the Sturgeons.)

Genus *ACIPENSER*, Linnæus.

172. *Acipenser maculosus* Le Sueur. SPOTTED STURGEON. (M. V. 345; Nelson 51.)

Ohio and Mississippi rivers, probably not in the Lake.

173. *Acipenser rubicundus* Le Sueur. LAKE STURGEON. (M. V. 345; Nelson 51.)

Very abundant in the Lake; whether found in the Mississippi or not I do not know.

Genus *SCAPHIRHYNCHOPS*, Gill.

174. *Scaphirynchops platyrhynchus* (Raf.) Gill. SHOVEL-NOSED STURGEON. (M. V. 345; Nelson 51.)

Common in the Ohio and Mississippi rivers. Ohio R., Cairo; Ill. R., Peoria.

Class MARSIPOBRANCHII.

Order HYPEROARTIA.

Family PETROMYZONTIDÆ, (the Lampreys.)

Genus *AMMOCŒTES*, Dumeril.

175. *Ammocœtes niger* (Raf.) Jor. SMALL BLACK LAMPREY. (M. V. 349; *Petromyzon niger* Nelson 52.)

Common in small streams in many places, ascending to spawn in the spring. Pecatonica R., Freeport.

176. *Ammocœtes argenteus* (Kirt.) Jor. SILVERY LAMPREY. (M. V. 349; *Ichthyomyzon argenteus* Nelson 52.)

Probably more or less abundant through the state. Ill. R., Pekin.

177. *Ammocœtes hirudo* (Grd.) Jor. LEECH LAMPREY. (M. V. 350; *Ichthyomyzon hirudo* Nelson 52.)

A species supposed to be the one to which Girard gave the name of *hirudo* is quite abundant in the Mississippi and lower Ohio. *Ohio R., at Cairo.

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* Where exact localities are given in the preceding paper, they are in nearly every case taken from specimens now in the Laboratory, collected by myself or my assistants. S. A. F.

THE FOOD OF ILLINOIS FISHES.

By S. A. FORBES.

But little has been written on the food of the fresh water fishes of this country, and nothing whatever, so far as I can learn, on the food of the fishes of of this state. I have not found anything more elaborate than a short paper* by Prof. S. I. Smith, of Yale College, on the food of a few specimens of White Fish, Red Horse (*Myxostoma aureolum*), Yellow Perch and Sturgeon (*Acipenser rubicundus*), from Lakes Superior and Erie. An item † relating to the food of the White Fish was published by Dr. Stimpson, of the Chicago Academy of Sciences, in 1870, and a few scattered notes of single observations occur in various papers on classification. ‡

The importance of the subject, both to the scientific student and to the practical fish breeder, seems to warrant more systematic work; and a methodical investigation has therefore been begun at the State Laboratory, the first results of which are given in the following memoranda.

PURPOSES OF THE INVESTIGATION.

A thorough knowledge of this subject should contribute something to our theories of distribution, since the food of those forms having appetites at all discriminating must have much to do with their range. Light might even be thrown upon past distribution, and the causes be suggested of extensive migrations. The chosen *haunts* of different groups within their habitat, are probably determined largely by their gastronomic needs and preferences. Do the wide-spread species eat similar articles throughout their range, or are they wide-spread because they are omnivorous, or because their food habits are more *flexible* than those of other fishes? On the other hand, are the narrowly limited species ever restricted by the local character of their food?

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* Report of U. S. Commissioner of Fish and Fisheries, Pt. II, p. 690.

† American Naturalist, Sept. 1870, p. 403.

‡ A paper by Dr. C. C. Abbot in the Report of the U. S. Fish Commissioner for 1875-6 will also repay examination.

We ought also to gain, by this means, some addition to our knowledge of the causes of variation, of the origin and increase, the decline and extinction of species, and of the remarkable persistence of such forms as the river gar. What groups crowd upon each other in the struggle for subsistence? Do closely allied species, living side by side, ever compete for food? What relation, if any, do specific and generic differences bear to differences of food? These, and many similar questions, may not improbably be helped toward a solution.

Several *structures* not now fully understood, ought to receive their explanation. The variously developed grinding surfaces on the pharyngeal teeth of some cyprinoids, the differences in the structure of the gill-rakers among sun-fishes and of the lips among suckers, are cases in point.

It seems likely, however, that the food habits of fishes will be found, like their structure, much less highly differentiated than those of birds. This is what we should expect *a priori*, and it is indicated by the observations I have made upon both classes.* Prominent peculiarities, having apparently an important bearing upon the taking of food, will probably be found merely to extend a little the capacities of the species, or to enable it to take those slight advantages of its competitors when the struggle for existence comes to the death grapple, which after all are sufficient to decide the contest. To bring out such facts as this, a great number of observations will be necessary, covering all varieties of circumstance, and made with reference to the relative proportions of the different elements in the food of each species. The Top Minnows, for example, will probably be found to take the surface-swimming insects *more frequently* than the *Cyprinidae* do, but not by any means to depend on them *chiefly*.

Really *intelligent fish-culture*, on any large scale, implies a full acquaintance with the food of the native species. It is a matter of especial importance that the predaceous fishes should all be known, as well as the kinds of fishes on which each chiefly preys. A knowledge of the food of all species worth saving is, of course, indispensable, in order that proper measures may be taken to preserve their food supplies. It will also be of interest to know what fishes there are at once worthless for human food and harmless in their habits, and therefore worth encouraging, or perhaps even hatching, as food for the more valuable "game fishes." The gizzard shad (*Dorosoma cepedianum*), seems to be a fish of this character, as it lives chiefly on vegetable food and minute crustacea, and contributes largely to the food of the marketable fishes. Apparently ignorant of this fact, the fishermen often leave long lines of this species to rot on the bank where the seines are hauled.

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* See "The Food of Birds," in Trans. Ill. Hort. Soc., Vol. X, p. 37, 1876.

Some valuable fishes may be found dependent on food too liable to injury or destruction by man or nature, to make it worth while to cultivate them, while others, equally valuable, may be proven to subsist on food practically indestructible.

Such species as eat *mixed food*, so that, in case of scarcity of one kind, another may be drawn upon, are evidently more promising, other things being equal, than those of a more limited diet.

That a full understanding of the *competitions* among the fishes of a stream or lake is necessary to anything better than guess-work in fish-culture, or an expensive and improvident trusting to luck, is evident at once. *

The *scavenger* fishes, which, by devouring the filth of streams, help to purify them, are doubtless worthy of recognition. Whether a filth-eating fish is better or healthier food than a bird or a mammal of similar habits, may, perhaps, be profitably discussed.

An acquaintance with the subject sufficient for the purposes above mentioned must, of course, include the whole life of the fish, at all ages and in all seasons. It is not impossible, for example, that the draining of stagnant waters connected with a stream may unfavorably affect some of its fishes, by lessening the supply of *Entomostraca*, especially *Cladocera*, for the food of the fry.

So much may properly be said concerning the purpose and promise of the research, to justify the labor given to it,—especially since the general neglect it has received may seem to indicate that it is not worth elaborate study.

METHODS.

The stomachs and intestines were taken out of the fishes just as these came from the seine; were labeled with specific name, place and date, and preserved in strong alcohol. They were afterward opened and the contents examined (usually with the microscope). Notes were made upon the objects found in each, as far as they were recognizable—the species being determined, if possible, otherwise the genus, family, order, or even only the class. The contents of each stomach were then bottled separately in alcohol, labeled and preserved for future verification and further study. The emptied stomachs have also been kept for anatomical purposes, and as a means of verifying the species. It was found unnecessary to remove the stomachs of the minnows, as these were well enough preserved in the bodies of the fishes themselves.

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* That fishes and land birds should ever come into competition, seems at first sight remarkable; nevertheless some of the former eat large numbers of land insects which fall into the water. The supply of these would, of course, be limited by the depredations of birds.

In summing up, all the notes on the food of each species were collated, and an attempt was made to arrange the essential facts in a compact and simple form. The classification of fishes used is that of the preceding paper on the fishes of Illinois.

RESULTS.

Only a mere beginning has as yet been made. One hundred and forty-nine specimens have been examined, representing fifty-four species—taken chiefly (except the minnows) from the Illinois River, near Peoria and Henry, in June and November, 1877, and April and May, 1878. The specimens were all of a fair average size. In this preliminary report upon so small a number of specimens, it has not been deemed worth while to specify dates and places.

When the facts relating to any species are numerous and varied enough to make systematic condensation desirable, the articles of food have been arranged according to the natural classification of plants and animals, in such a way that one wishing to know only the general conclusions reached can readily learn them, without being embarrassed by unessential details.

The importance of a knowledge of the *proportions* of the different elements of the food has been kept in mind, and an attempt made to indicate these rudely by placing after each the number of specimens of the species in which the given element was found. Thus, under *Lepiopomus pallidus* (No. 18), of which two specimens were examined, "Chrysomelidæ 2" indicates that *one or more beetles* of this family were found in the stomachs of each of *two specimens* of that species. The figures in parentheses placed after the family and specific names of *fishes* indicate the number of specimens examined.

DETAILS OF FOOD.

DARTERS. ETHEOSTOMATIDAE. (9.)

Entomostraca and larvae of diptera and neuroptera.

1. *Sand Darter.* Pleurolepis pellucidus, Ag. (2.) Larvae of small diptera.

2. *Black-sided Darter.* Alvordius maculatus, Grd. (1.) Small diptera (gnats), larvae of May-flies (Ephemeridae), and many unknown minute eggs ?, oval, tuberculated, with tubercles in longitudinal rows.

3. *Johnny Darter.* Boleosoma maculata, Ag. (1.) Several Cyclops and many larvae of gnats.

4. *Banded Darter.* Nanostoma zonalis, Put, (1.) Larvae of gnats, including some with antennae similar to those of Corethra pictipennis.

5. *Rough-cheeked Darter.* Poecilichthys asprigenis, Forbes, (2.) Larvae of Chironymus (diptera), and other aquatic larvae; also pupae of a small Ephemerid approaching Baetisca.

6. *Striped Darter.* Etheostoma lineolata, Ag. (1.) Many larvae of Chironymous (diptera).

7. ——— ——— Boleichthys elegans, Gir. (1.) Larvae of gnats and of May-flies, with a few copepoda.

PERCHES. PERCIDAE. (7.)

Chiefly fishes, including perch, bass, sun-fish, gizzard shad, minnows, (Cyprinidae) and cat-fish; also water-bugs (Corixa).

8. *Ringed Perch.* Perca americana, Schrank, (1). A cyprinoid fish.

9. *Black "Salmon." Wall-eyed Pike.* Stizostethium vitreum, Mitch. (1). A bony fish with sub-globular stomach; probably one of the suckers.

10. *White "Salmon." Wall-eyed Pike.* Stizostethium canadense, Smith, (4). A common perch (Perca), a sun-fish (Ichthelidae), a black bass (Micropterus salmoides), a gizzard shad (Dorosoma), a cat-fish (Siluridae), and an undetermined bony fish with cycloid scales.

11. *Wall-eyed Pike.* Stizostethium, (species undetermined) (1). An unrecognizable bony fish and several water-bugs (Corixa alternata, Say).

WHITE BASS. LABRACIDAE. (4.)

Sun-fish, larvae of neuroptera and diptera, and other insects.

12. *White Bass.* Roccus chrysops, Raf. (3). Chiefly larvae of May-flies (Ephemeridae); also a sun-fish, (Centrarchidae) and another spiny-finned fish, and a few larvae of Chironymous and other diptera.

13. *Yellow Bass.* Morone interrupta, Gill. (1). Chiefly larvae of Ephemeridae (May-flies). An amphipod crustacean (Allorchestes dentata, Sm.), some larvae of dragon flies (Agrion) and a few young grasshoppers.

BLACK BASS AND SUN FISHES. CENTRARCHIDAE. (31.)

Food mixed, animal and vegetable, the former largely predominating. A few fishes (a darter, another percoid fish, and two or three cyprinoid minnows), a multitude of insects, land and water, representing all orders but hymenoptera; arachnida (spiders and water mites), amphipod and isopod crustacea (Allorchestes and Asellus), hosts of entomostraca (cladocera and copepoda, chiefly the former), a few mollusks, bivalve and univalve, an earth worm, and masses of Plumatella-like polyzoa; also a good deal of Potamogeton, Ceratophyllum and other water weeds, and algae, together with miscellaneous floating vegetable trash.

14. *Black Bass.* Micropterus pallidus, Raf. (3). A large mouse, a percoid fish, a small stone roller (Campostoma anomalum), pupae of dragon flies, a water bug (Zaitha fluminea) and a few confervoid algae.

15. *Black Croppie.* Pomoxys nigro-maculatus Le S.(10). Chiefly larvae of May-flies (Ephemeridae). Many larvae of small diptera (various species of gnats), and occasionally a small percoid fish. The following is a detailed exhibit of the food of these ten specimens :

FISHES (Ctenoid.) 2.

INSECTS 10.

COLEOPTERA 3 (Larvae of Gyrinidae 2.)
DIPTERA 6 (Gnats and their larvae.)
HEMIPTERA 2 (Corixa alternata, Say.)
NEUROPTERA 9 (Larva of Ephemeridae 8, pupae of Agrioninae 1).

CRUSTACEA 3 (Entomostraca.)

CLADOCERA 2 (* Ceriodaphnia angulata (Say) Forbes 2). * Bosmina (Sp. ? 1).
COPEPODA 1 (Diaptomus).
POLYZOA Sp ? 1.

A few seeds and blossoms of trees in 2.

16. *White Croppie.* Pomoxys annularis, Raf. (9). Specimens taken in midsummer were feeding chiefly on the larvae of May flies. A number collected in March were distended with Ceriodaphnia angulata and larvae of may flies and dragon flies (Agrioninae). A small fish was found occasionally, and a few water bugs.

FISHES 4.

Etheostomatidae 1, Cyprinidae 1 (Luxilus analostanus), undetermined cycloid fish 1.

INSECTS 8.

COLEOPTERA 1 (larvae of Gyrindae).
HEMIPTERA 1 (Corixa alternata, Say).
NEUROPTERA 8 (Larvae of Ephemeridae 5, of Agrioninae 5).

CRUSTACEA 5 (Entomostraca).

Ceriodaphnia angulata, Say, 5.

17. *Croppies.* Pomoxys, Sp. undet. (2). A cyprinoid minnow, a few spiders, a hemipter, and larvae of May flies.

18. *Common Sun Fish. Blue Sun Fish.* Lepiopomus pallidus, Mit. (5). Almost wholly insects (many of them terrestrial.) A few mollusks and a little pond weed (Potamogeton).

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* See appendix.

INSECTS 4.

LEPIDOPTERA 2 (Caterpillars).

COLEOPTERA 3,—Carabidae 1 (Agonoderus pallipes), Gyrinidae 1 (larva), Scarabaeidae 1 (Aphodius inquinatus), Chrysomelidae 2 (Diabrotica 12—guttata and a Haltica ?).

DIPTERA 2 (larvae of gnats).

ORTHOPTERA 1 (Phaneroptera curvicauda, a Tettix and a cricket.)

HEMIPTERA 3 (Corixa alternata 2, Arma ? 1).

NEUROPTERA 2 (Larvae of Ephemeridae.)

ARACHNIDA 3.

Spiders 2, Hydrachnidae (water mites) 1.

MOLLUSKS, 2.

Gasteropoda 2 (Physa, Planorbis).

Also an earthworm, some Potamogeton, and a number of unrecognized small seeds.

19. *Blue-cheeked Sun-fish.* Lepiopomus ischyrus, Nels. (1). Full of hornwort (Ceratophyllum demersum) and a polyzoan (Plumatella ?); also fragments of small bivalve shells, some small crustacea (Asellus, * Allorchestes dentata, Sm., and Cypris, sp.) and a little mixed vegetable matter.

20. *Bream. Pumpkin Seed.* Eupomotis aureus, Walb. (1). Several Aselli, univalve mollusks, and some unrecognized vegetable matter.

PIRATE PERCHES. APHODODERIDAE.

21. *Western Pirate Perch.* †Aphododerus isolepis, Nels. (3). The largest specimen (3 in. long) had eaten several Aselli, some larvae of diptera, a Corixa and another water-bug—apparently a Galgulus. The second in size ($2\frac{1}{4}$ in.) contained only a small cycloid fish and several larvae of neuroptera. In the stomach of the smallest were several ostracoda (Cypris,) a larval Corixa and a few gnats.

MAIGRES. SCIAENIDAE.

22. *Sheepshead.* Haploidonotus grunniens, Raf. (7). Mollusks and larvae of May flies, with a few larvae of gnats.

Unios 2, Planorbis 2, Limnea 1, Ephemeridae 6, diptera 2.

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* See appendix.

† An observation of the intestines shows that one effect of the remarkable change in the position of the vent in this species is the lengthening of the alimentary canal and a consequent increase of the digestive surface. The intestine passes from its origin at the stomach first upward, then backward, then downward, reaching the ventral wall at a point about half way from the bases to the tips of the ventrals. In the smallest specimens, it opens at this point. In the others, it turns forward along the middle line of the belly, and opens at a point more or less to the front, according to the size of the fish, leaving a seam of naked skin behind.

STICKLEBACKS. GASTEROSTEIDAE.

23. *Brook Stickleback.* Eucalia inconstans, Kirt. (1). Entomostraca (Cyclopidae and Eurycercus), and many mulberry-like masses of eggs (mollusks ?)

SILVERSIDES, ATHERINIDAE.

24. *River Silverside.* Labidesthes sicculus; Cope. (5). Chiefly minute crustacea (copepoda and cladocera). A few small diptera and larvae of small dragon flies.

Cyclopidae 3, Daphniadae 3, (Bosmina,* Daphnia *), Lynceidae 1, (Eurycercus *), small diptera 3, larvae of Agrioninae 1.

TOOTHED MINNOWS. CYPRINODONTIDAE. (7).

Chiefly insects, aquatic and terrestrial; crustacea (amphipoda and cladocera), and gasteropod mollusks.

25. *Barred Killifish.* Fundulus diaphanus, Le S. (2). Planorbis and Pisidium, larvae of small diptera, Allorchestes, and cladocera of the family Lynceidae.

26. *Top Minnows.* Zygonectes notatus, Raf. (3). Bones of a small fish. Several small winged hymenoptera, small wingless ants, a spring beetle (Elateridae), a few hemiptera, several diptera and diptera larvae and pupae, a small spider, Crangonyx gracilis, and a number of Daphniidae and Lynceidae (Eurycercus, &c.)

27. *Striped Top Minnow.* Zygonectes dispar, Ag. (2). Physa and Planorbis, hemiptera and small diptera, and a few Lynceidae.

MUD MINNOWS. UMBRIDAE.

28. *Mud Minnow.* Melanura limi, Kirt. (2). Many water mites (Hydrachnidae), diptera larvae, Cypris, Planorbis, and fragments of unrecog nizable insects.

PIKES. ESOCIDAE. (8.)

Fishes of several families, and tadpoles.

29. *Northern Pike.* Esox lucius, L. (8.) Only fishes. The eight specimens contained remains of 12 fishes, among which were a black bass (Ambloplites rupestris), and another ctenoid fish, a gizzard shad (Dorosoma), a toothed herring (Hyodon), 3 cyprinoids (1 Campostoma anomalum and 1 Alburnops ?), an Ichthyobus and another large cycloid fish.

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* See appendix.

30. *Little Pickerel.* Esox salmoneus, Raf. (2.) A small fish and two tadpoles of frogs.

MOON EYES. HYODONTIDAE.

31. *Toothed Herring.* Hyodon tergisus, Le S. (3). Numerous insects, including a bee, carabid beetle, some aquatic hemiptera, numerous larvae of Ephemeridae; a remarkable crustacean of which but a single specimen has hitherto been found in this country (Leptodora hyalina,* Lillj.); some rotten wood, elm seeds and other vegetable trash, evidently gathered from the drift-wood where one of the specimens had found its food.

HERRINGS. CLUPEIDAE. (6.)

32. *Ohio Golden Shad.* Pomolobus chrysochloris, Raf. (1.) A small bony fish and a few fragments of insects.

33. *Gizzard Shad. Hickory Shad.* Dorosoma cepedianum, Le S., var. heterurum, Raf. (5.) Extremely dirty. Every stomach examined was at least half full of mud. The food was chiefly vegetable, consisting largely of algae and a few crustacea, such as would naturally be entangled in the vegetation eaten. The objects recognized were a few diptera larvae, Leptodora hyalina, Cypris, Cyclops, masses of Chara, confervoid algae, desmids, and vast numbers of diatoms.

MINNOWS. CYPRINIDAE. (15.)

Time has failed for the examination of any sufficient number of this family, some of the most important genera having been omitted entirely. Enough has been learned, however, to show that these fishes live, some chiefly on aquatic vegetation (especially algae) and others on insects, of which small diptera and their larvae seem to constitute the greater part. The section whose teeth are not hooked probably eat vegetable food more largely than those with raptatorial teeth, no insects at all having been found in the intestines of the five specimens of that section examined.—I found a surprising amount of dirt in the intestines of these herbivorous minnows,—too much, I think, to have been taken incidentally.

34. *Stone Roller.* Campostoma anomalum, Raf. (1.) Full of dirt and confervoid algae.

35. *Blunt-nosed Minnow.* Hyborhynchus notatus, Raf. (3.) Full of dirt, with fragments of endogenous vegetation, confervoid algae, and many diatoms.

36. *Silvery Minnow.* Hybognathus argyritis, Grd. (1.) Full of sand and an immense number of diatoms, with a few filaments of confervoid algae and fragments of other vegetable matter.

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*See appendix.

37. *Red-finned Shiner.* Luxilus cornutus, Mit. (2.) Chiefly vegetable. Fragments of unrecognizable insects, a mass of confervoid algae and parts of a netted-veined leaf.

38. *Silver Fin.* Luxilus analostanus, Gir. (3.) Insects of several orders and a few algae.

39. *Red Fin.* Lythrurus diplaemius, Raf. (1.) A few small diptera.

40. *Emerald Minnow.* Notropis atherinoides, Raf. (2.) Several small gnats, an unknown hemipter and a little vegetable matter.

41. *Silver-mouthed Dace.* Ericymba buccata, Cope. (1.) A few small larvae of diptera, much sand and indeterminable matter, partly vegetable.

42. *Common Chub.* Semotilus corporalis, Mit. (1.) Many Ephemera larvae and a larva apparently belonging to the Dytiscidae.

SUCKERS. CATOSTOMIDAE. (24.)

My observations on this family indicate that its food is chiefly animal, consisting principally of mollusks, insect larvae and entomostraca. It is not impossible that in this, as in some other cases, the proportion of vegetable food is under-estimated, owing to the rapidity with which it is digested, as compared with the chitinous and calcareous coverings of arthropods and mollusks. The intestines of the family contain usually large quantities of mud.

There seems to be a well defined difference between the food of the Catostominae (Red Horse) and that of the Bubalichthyinae (Buffaloes), the former group feeding much more freely on mollusks than the latter, and less generally on entomostraca. Of the eight Myxostomas examined, the principal food of each was small, thin-shelled Unionidae (Anodonta), while no entomostraca at all were observed in them, and annulate worms (Naididae) were found in but two specimens. On the other hand, mollusks were found in only four out of fourteen carp and buffaloes (gasteropods 2, bivalves 2), and in these insignificant in quantity, while large numbers of entomostraca were noticed in twelve of the specimens. The intestines of many of the buffaloes were filled with a yellowish, shreddy, corpuscular fluid which I could only interpret as altered intestinal mucus and broken down membrane. The fishermen at Peoria report, however, that these fishes frequent the mouths of the gutters from the still-houses of which the river front is redolent, apparently feeding upon the distillery slops.

43. *Red Horse.* Myxostoma macrolepidotum, Le S. (3.) Chiefly mollusks, (Unionidae, Physa, Planorbis.) A number of ringed worms (Naididae), fragments of Chara and endogenous vegetation, and much mud.

44. *Golden Red Horse.* Myxostoma aureolum, Le S. (2.) Chiefly mollusks, (Anodonta, Paludina), a few slender ringed worms (Naididae), much dirt and a little unrecognized vegetation.

45. Myzostoma, sp. undet. (3.) Only mud and Unionidae.

46. *Chub Sucker.* Eremyzon sucetta, Lac. (2.) Confervoid algae, diatoms, mud.

47. *Carp Suckers.* Carpiodes, sp. (6.) I have found it quite impossible to recognize the species of this genus with certainty by the descriptions extant, and until they have been revised prefer not to attempt to separate them.

Mollusca 1 (gasteropoda).

Insecta 3 (Chironomus larvae).

Crustacea 4; Cladocera 3 (Bosmina 1, Ceriodaphnia 1, Lynceidae 1), Ostracoda 2 (Cypris), Copepoda 3 (Cyclops 2, Canthocamptus 2.) Also nematoid worms 1, and various algae 2.

48. *Red-mouth Buffalo.* Ichthyobus bubalus, Raf. (6.) Chiefly entomostraca.

Mollusca 1 (Limnea ?).

Insecta 4 (larvae of diptera.)

Crustacea 6, Cladocera 5, (Bosmina 4, Daphnia 2, Ceriodaphnia angulata 4, Lynceidae 2) Ostracoda 2 (Cypris), Copepoda 5 (Cyclops 5, Canthocamptus 1). Also diatoms 1, and seeds and glumes of grasses 1.

49. *Black Buffalo.* Bubalichthys niger, Raf, (2.) Larvae of gnats and May flies, Unionidae, Ceriodaphnia, Cyclops, a Lumbricus, diatoms, mud.

CAT FISHES. SILURIDAE, (8.)

Very miscellaneous feeders, eating both animal and vegetable food, the former the more freely. Bones and pieces of fish were found, evidently from too large animals to have been swallowed alive. Aquatic larvae of all kinds, worms, water bugs, mollusks (rarely), algae, stems and leaves of both exogens and endogens, masses of fine roots, with an occasional craw-fish make up the bill of fare.

50. *Common Channel Cat.* Ichthaelurus punctatus, Raf. (6.) Bones and pieces of large fishes 3, fragments of bivalve mollusks (no shells) 1, land insects 1 (bees, plant bugs), aquatic larvae 6 (Dytiscidae, Agrioninae

and other dragon flies, May flies, caddis flies), water bugs, 1 (Corixa and Notonecta), vegetable matter 4, (algae, Naiadaceae, roots stems and leaves of various plants).

51. *Black Cat Fish.* Amiurus melas, Raf. (2). Taken in small prairie creeks, McLean Co. Stomach of one was full of purely vegetable food, consisting chiefly of a mass of confervoid algae ; that of the other contained no vegetation, but exhibited fragments of various insects, some of them terrestrial, and remains of young craw-fishes and aquatic larvae.

DOG FISHES. AMIIDAE.

52. *Dog Fish. Grinnel.* Amia calva, L. (1.) A single small specimen, 5 in. long, from S. Ill., had eaten some Ephemera larvae, a few ostracoda (Cypris) and some confervoid algae, with numerous diatoms.

GAR PIKES. LEPIDOSTEIDAE.

53. *Broad-nosed Gar.* Lepidosteus platystomus, Raf. Seven or eight specimens were opened, but the stomachs of all but one were entirely empty. This one contained a common river craw-fish, (Cambarus immunis, Hagen.) Is the gar a nocturnal feeder?

SPOON-BILLED CATS. POLYODONTIDAE.

54. *Shovel Fish. Bill Fish.* Polyodon folium, Lac. (5.) This is by far the most remarkable fish in our rivers, and is not less remarkable in its food than its structure. By the fishermen it is supposed to live on the slime and mud of the river bottom. The alimentary canal of each of the five specimens examined was found full of a brownish, half fluid mass, which, when placed under the microscope, was seen to be made up chiefly (in one case almost wholly) of countless myriads of entomostraca, of nearly every form known to occur in our waters, including many that have been seen as yet nowhere but in the stomachs of these fishes. Mixed with these, in varying proportion, were several undetermined and probably undescribed species of water worms (Annulata), most of them belonging to the family Naididae. Sometimes as much as a fourth of the mass was composed of vegetable matter,—largely algae, but including fragments of all the aquatic plants known by me to occur in the waters of the Illinois, except Ceratophyllum. Occasional leeches (Clepsine), water beetles (Coptotomus interrogatus &c.), a few larvae of diptera and Ephemerae and water bugs (Corixa) were noticed. Among the crustacea several specimens of the remarkable Leptodora hyalina already referred to were found.

I have not had time for anything more than a general examination of the mass of matter presented,—sometimes more than a pint from a single fish, —and cannot, therefore, give a list of the species. Curiously, very little mud was mixed with the food.

The remarkably developed gill-rakers of this species thus receive their explanation. These are very numerous and fine, arranged in a double row on each gill arch, and are twice as long as the filaments of the gill. By their interlacing they form a strainer scarcely less effective than the fringes of the baleen plates of the whale, and probably allow the passage of the fine silt of the river bed when this is thrown into the water by the shovel of the fish, but arrest everything as large as a Cylops. The fish is said by the fishermen to plow up the mud in feeding, with its spatula-like snout, and then to swim slowly backward through the muddy water. Its mouth, it may be noticed, is very large, even for a fish.

It is possible that this wholesale destruction of entomostraca may affect the food supply of other and more valuable fishes, especially of the very young of the predaceous species. We cannot yet say, however, where the *stress* of the struggle comes in the life of any given species, and consequently are unable either to relieve or heighten it at will, or to perceive the full effect of the forces already at work. Fuller knowledge must precede any but the most cautious and conservative recommendations.

RECAPITULATION.

A summary of the leading facts presented in this paper is given in the following table. The figures taken from left to right give, in a general way, the food of each family and species, and taken vertically show the fishes which eat any given kind of food. The line of totals will show something of the relative importance to fishes as a class of the different food elements. The figures in the table have the same use as those in the preceding list, showing the *number of specimens* of the given species found to eat the food mentioned at the head of the column.

It will be seen that, estimated in this way, the most important kinds of food are insects, crustacea, plants, fishes and mollusks, in the order named. These data apply entirely to adult fishes, however; if the young were also taken into account, crustacean food would doubtless be found more important.

The best food fishes ("fine fish" of the markets—Percidae, Labracidae, Centrarchidae, Esocidae) are chiefly piscivorous, except the Centrarchidae, which are nearly omnivorous, but prefer insects. Scarcely any fishes examined, except some Cyprinidae, can be called strictly herbivorous, although the gizzard shad (Dorosoma) is chiefly so, the animal food taken being probably incidental.

That the sheepshead, with its enormous crushing pharyngeals, should eat fewer mollusks than the red-horse, was scarcely to be expected, and may yet prove untrue.

Cat-fishes are the only ones shown to be scavengers. The fishermen, however, attribute similar habits to sheepshead and buffalo-fish.

Cyprinidae seem to be divided into two sections, corresponding to the shapes of the pharyngeal teeth, those without raptatorial hooks being herbivorous.

All these general statements ought, perhaps, to be put in the form of questions for future solution, since the number of specimens is too small and the space and time represented too limited to justify settled conclusions.

No. on List.	Names of Fishes.	No. examined.	FISHES.	Ctenoid.	Cycloid.	Siluroid.	MOLLUSKS.	Univalve.	Bivalve.	INSECTS.	*Terrestrial.*	Hymenoptera.	Lepidoptera.	Diptera.	Coleoptera.	Orthoptera.	Hemiptera.	Neuroptera.	*Aquatic.*	Diptera.	Coleoptera.	Hemiptera.	Neuroptera.	ARACHNIDA.	Araneidae.	Hydrachnidae.	MYRIAPODA.	CRUSTACEA.	Decapoda.	Tetradecapoda.	Entomostraca.	WORMS.	POLYZOA.	PLANTS.	Phaenogam.	Cryptogam.	GARBAGE.
	Etheostomatidae	9								9									9	7			4					2			2						
1	Pleurolepis pellucidus	2								2									2	2																	
2	Alvordius maculatus	1								1									1	1			1														
3	Boleosoma maculatum	1								1									1	1								1			1						
4	Nanostoma zonale	1								1									1	1																	
5	Poecilichthys asprigenis	2								2									2	1			2														
6	Etheostoma lineolatum	1								1									1	1																	
7	Boleichthys elegans	1								1									1	1			1					1			1						
	Percidae	7	7	3	4	1																1															
8	Perca americana	1	1		1																																
9	Stizostethium vitreum	1	1		1																																
10	S. canadense	4	4	3	2	1																															
11	Stizostethium, sp	1	1																			1															
	Labracidae	4	2	2						4	1					1			4	3			3					1		1	1						
12	Roccus chrysops	3	2	2						3									3	3			3														
13	Morone interrupta	1								1	1					1			1				1					1		1	1						
	Centrarchidae	31	8	4	5		4	3	1	25	4	1	2	1	3	1	2		24	3	5	5	21	4	3	1		10		2	9	1	2	4	2	1	
14	Micropterus pallidus	3	2	1	1					1				1					1			1	1											1		1	
15	Pomoxys nigro-maculatus	10	2	2						10	1								10	1	3	2	9					3			3		1				
16	P. annularis	9	3	1	2					8									8		1	1	8					5			5						
17	Pomoxys, sp	2	1		1					2									2			1	1	1	1												
18	Lepiopomus pallidus	5					2	2		4	3	1	2		3	1			3	2	1	2	2	3	2	1						1		1	1		
19	L. ischyrus	1					1		1																			1		1	1		1	1	1		
20	Eupomotis aureus	1					1	1																				1		1				1			
	Aphododeridae																																				
21	Aphododerus sayanus *	3	1		1					3	1			1					3	1		2	1					2		1	1						
	Sciaenidae																																				
22	Haploidonotus grunniens	7					3	2	2	6									6	2			6														

* While these pages are being printed, I learn from Dr. Jordan that he finds no constant differences between the eastern and western forms of Aphododerus.

No. on List.	Names of Fishes.	No. examined.	FISHES.	Ctenoid.	Cycloid.	Siluroid.	MOLLUSKS.	Univalve.	Bivalve.	INSECTS.	*Terrestrial.*	Hymenoptera.	Lepidoptera.	Diptera.	Coleoptera.	Orthoptera.	Hemiptera.	Neuroptera.	*Aquatic.*	Diptera.	Coleoptera.	Hemiptera.	Neuroptera.	ARACHNIDA.	Araneidae.	Hydrachnidae.	MYRIAPODA.	CRUSTACEA.	Decapoda.	Tetradecapoda.	Entomostraca.	WORMS.	POLYZOA.	PLANTS.	Phaenogams.	Cryptogams.	GARBAGE.
	Gasterostidae																																				
23	Eucalia inconstans	1																										1			1						
	Atherinidae																																				
24	Labidesthes sicculus	5								3	3			3					1				1					5			5						
	Cyrinodontidae	7	1				3	3		7	4	1		2	1		2		4	4				1	1			5		2	5						
25	Fundulus diaphanus	2					1	1		2									2	2								2		1	2						
26	Zygonectes notatus	3	1							3	3	1		2	1		1		1	1				1	1			2		1	2						
27	Z. dispar	2					2	2		2	1						1		1	1								1			1						
	Umbridae																																				
28	Melanura limi	2					1	1		2									1	1				2		2											
	Esocidae																																				
29	Esox lucius	8	8	3	7																																
30	E. salmoneus, (tadpoles 1)	2	1																																		
	Hyodontidae																																				
31	Hyodon tergisus	3								3	2	1			1				3		1	1	2														
	Clupeidae																																				
32	Pomolobus chrysochloris	1	1							1																											
33	Dorosoma cepedianum	5								3									3	3								2			2			4	4	1	
	Cyprinidae	15								10	5	1		3	2				5	3	1		1					1			1			8	2	6	
34	Campostoma anomalum	1																																1		1	
35	Hyborynchus notatus	3																																3		2	
36	Hybognathus argyritis	1																																1	?1	1	
37	Luxilus cornutus	2								2																								1	1	1	
38	L. analostanus	3								3	2				2				3	2								1			1			1		1	
39	Lythrurus diplaemius	1								1	1			1																							
40	Notropis atherinoides	2								2	2	1		2																							
41	Ericymba buccata	1								1									1	1														1			
42	Semotilus corporalis	1								1									1		1?		1														

No. on List.	Names of Fishes.	No. examined.	FISHES.	Ctenoid.	Cycloid.	Siluroid.	MOLLUSKS.	Univalve.	Bivalve.	INSECTS.	*Terrestrial.*	Hymenoptera.	Lepidoptera.	Diptera.	Coleoptera.	Orthoptera.	Hemiptera.	Neuroptera.	*Aquatic.*	Diptera.	Coleoptera.	Hemiptera.	Neuroptera.	ARACHNIDA.	Araneidae.	Hydrachnidae.	MYRIAPODA.	CRUSTACEA.	Decapoda.	Tetradecapoda.	Entomostraca.	WORMS.	POLYZOA.	PLANTS.	Phaenogams.	Cryptogams.	GARBAGE.
	Catastomidae	24					11	5	9	11									9	9			1					11		5	10			10		7	
43	Myxostoma aureolum	2					2	1	2	1									1	1											1			1			
44	M. macrolepidotum	3					2	2	2	1									1	1											1			1			
45	Myxostoma, sp.	3					3		3																												
46	Erimyzon sucetta	2																																2		2	
47	Carpiodes, sp.	6					1		1	3									1	1								4		4	1			2		2	
48	Ichthyobus bubalus	6					1		1	4									4	4								6			6			3	1	2	
49	Bubalichthys niger	2					2	2		2									2	2			1					1		1	1			1		1	
	Siluridae																																				
50	Ichthaelurus punctatus	6					1			6	1	1					1		6		1	1	6											4	1	3	3
51	Amiurus melas	2								1	1				1													1	1			1		1	1	1	
	Amiidae																																				
52	Amia calva	1								1									1				1					1			1			1		1	
	Lepidosteidae																																				
53	Lepidosteus platystomus	1																										1	1								
	Polyodontidae																																				
54	Polyodon folium	5																	5	5	2	2	3					5				5		5	3	5	
	TOTAL	149	30	12	17	1	22	14	12	95	22	5	2	9	8	2	5	..	75	41	10	13	50	7	4	3	1	46	2	16	37	7	2	35	14	25	3

NOTE.—I have just succeeded in obtaining, too late for previous notice, a copy of an elaborate paper on the Fisheries of the Great Lakes, by Mr. J. W. Milner, Asst. U. S. Fish Commissioner, published in the first report of the commissioner, 1872-3. It contains full notes on the food of the White Fish, Lake Trout, Lake Herring and Sturgeon. An article by Prof. A. E. Verrill in the same report contains interesting matter for a comparison of the food of allied marine and fresh water species.

APPENDIX.

ON THE CRUSTACEA EATEN BY FISHES.

I have recognized the following genera and species of crustacea in the stomachs of the fishes of the preceding list, several of them being new to the state. The material afforded has been by no means exhaustively studied, and the list of species could probably be quadrupled. I have refrained from formal description of some species which are evidently new, preferring to wait for specimens in more perfect condition.

Cambarus immunis, Hagen.

This is the only craw-fish I have yet noticed in the stomachs of fishes, and this I have seen but once (in the short-nosed gar), unless young individuals eaten by a small cat-fish (*Amiurus melas*) also belonged to this commonest of our species.

Allorchestes dentata, (Smith) Faxon.

Specimens of *Lepiopomus pallidus*, taken in Crystal Lake, McHenry Co., in June, were feeding chiefly on this crustacean. It has also been found in the same species, in *L. ischyrus* and in *Morone interrupta* from the Illinois at Peoria.

Crangonyx gracilis, Smith.

The western form of this species (see Bull. No. 1, p. 6) occurs abundantly throughout central and southern Illinois. It is a very agile and voracious creature, behaving in a jar of entomostraca like a tiger in a sheep-fold. I have noticed that ponds in which it is at all common are nearly or quite destitute of *Eubranchipus*. The "handiness" with which it uses its anterior feet in feeding is quite amusing. I have found it eaten only by the Top Minnow (*Zygonectes notatus*.)

Asellus intermedius, Forbes.

Eaten by *Aphododerus* from Union Co. A species of *Asellus* described by Mr. O. P. Hay, in the paper following this, as *A. militaris*, has recently been collected in the Illinois River, and has been noted in the stomachs of

Lepiopomus ischyrus and *Eupomotis aureus*. Another form which, from its variability, I have not yet ventured to describe as distinct from *intermedius*, is very common in slow streams and fresh pools in McLean Co., especially in early spring, and has reached me also from La Salle Co., and from Wisconsin. Its size is equal to that of *communis*, and it differs from typical *intermedius* also in the much more robust development of all its appendages, and in the large size of the second joint of the outer ramus of the second genital plates of the male. The form and proportions of these genital plates must be used with caution, however, in describing species, as they evidently vary greatly.

Leptodora hyalina, Lilljeborg.

This extremely curious crustacean, which may be known by its peculiar, slender form (that of a true cross, the arms of which are the swimming appendages), by its extreme transparency and by the single eye in the front end of its cylindrical head, has hitherto been observed in this country only by Prof. S. I. Smith, by whom a single specimen was dredged in L. Superior in 1871.* It evidently stands between the other Cladocera and the Phyllopoda in many respects, having no slight resemblance to a larval *Eubranchipus.*

It occurs in considerable numbers in Peoria Lake, a mere expansion of the Illinois River, the depth of which does not exceed eighty feet. Specimens taken in a small surface net, in June, 1877, were lost in transit, and it was not again seen until found in the stomachs of *Polyodon*, *Dorosoma* and *Hyodon.* It is not at all certain that this is identical with the European species, all the specimens yet studied being too imperfect to decide this point.

Eurycercus lamellatus, Muell.?

Specimens apparently of this species appear in the stomachs of fishes from Crystal Lake, McHenry Co., (*Apeltes*, *Labidesthes*, *Fundulus*) and also in shovel fishes from Peoria Lake. It is likewise common in ponds in McLean Co.

Bosmina, sp.?

This genus belongs to a section of *Dapniadae* (*Lyncodaphnia*) distinguished by the long and strong anterior antennae and by the reduced importance of the posterior pair. The former are tapering, curved and cylindrical, (containing in our species about 14 slightly spinulose joints, with a tuft of bristles on the front of the third) and project from the front of the head like a bifid beak. Occurs in myriads in food of shovel fish, in carp, buffalo, &c., and in *Labidesthes* from Crystal Lake.

Ceriodaphnia angulata, (Say) Forbes.

Very abundant in central Illinois, (McLean and Rock I. counties), but

* Invertebrate Fauna of L. Superior, p. 696.

not hitherto reported. The following is Say's description, in Jour. Acad. Nat. Science, Phil., Vol. I, p. 440, 1818:

"*D. angulata.* Body viewed laterally, sub-oval, contracted before, gibbous above near the posterior edge, beneath ventricose in the middle; back sub-ovate, acute behind and contracted before; sides striate with numerous minute, parallel, obliqe lines. Hind edge of the body with a prominent angle in the middle, which is obtuse at tip; above the angle it is ciliated. *Antennae*, 4 filaments on the superior branch, and 5 on the inferior branch; color white or red. Length $\frac{1}{10}$ of an inch. Cabinet of the Academy. Very common in the stagnant marsh water of the forests of the Southern States."

In the Illinois specimens the head is marked off from the body by a dorsal indentation. The color is usually white. Found in the stomachs of carp, buffalo, sun-fish, &c. It constituted the principal part of the food of a number of croppies taken in April, from the Illinois R. The eggs beneath the carapace were so numerous as to give an orange color to the whole mass of the food at this time.

Daphnia pulex ? L.

The species referred to by Prof. Smith, under this name,* is our commonest *Daphnia*, occurring everywhere in immense numbers. It is eaten by *Polyodon* and by many small fishes.

Daphnia galeata, Sars.

A species probably the same as that figured by Prof. Smith in the paper already cited, was found in Crystal Lake,—a shallow sheet of water about 2 miles long—and was eaten in numbers by the abundant little silversides (*Labidesthes.*)

Canthocamptus illinoisensis, Forbes.

This minute crustacean was frequently found in carp, buffalo and shovel fishes from the Illinois R.

Diaptomus sanguineus, Forbes.

In *Pomoxys nigro-maculatus*. Numbers of the genus unrecognizable as to species were observed in a variety of fishes.

Many *Cyclops* and *Cypris*, the species of which I have not attempted to discriminate, occurred in fishes from all waters and of a dozen families.

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*Loc. cit.

DESCRIPTION OF A NEW SPECIES OF ASELLUS.

By O. P. HAY.

Asellus militaris. (*Sp. nov.*)

Length of male 17 mm., of female 11 mm. Color brown, ornamented with irregular shaped yellow spots, somewhat symmetrically arranged on each side of the median line. Feet and caudal stylets with a tinge of rose. Upper surface of the body covered with minute scattered hairs. All the free margins of the body abundantly furnished with slender spines; these longest on the lateral margin. Head narrow, only about one-half the width of the first thoracic segment; the anterior margin concave; antero-lateral angles obliquely truncated; lateral margins diverging posteriorly, with a small outwardly projecting lobe at the posterior angle; this lobe furnished with several short spines. Eyes comparatively small. Anterior segments of thorax concave in front, convex behind; becoming less so to fifth segment, whose anterior and posterior margins are nearly straight. Sixth and seventh segments convex in front, concave behind, the concavity being deepest in the seventh. All the thoracic segments after the second about the same width; the second a little narrower than the succeeding segments; the first about three-fourths as wide as the widest. Antero-lateral angles of first segment excavated and filled by the broad epimera. Second segment very slightly notched in front. In the succeeding segments this notch is pushed further back and becomes deeper, especially in the last three. As the notch becomes deeper, the antero-lateral angle is lengthened and turned backward. The epimera again make their appearance in the fifth, sixth, and seventh segments, only partially filling the lateral notches. Postero-lateral angles of all the thoracic segments rounded.

Abdomen sub-orbicular; width and length equal; anterior and posterior angles quite well marked. Posterior margin excavated at insertion of caudal stylets, prolonged behind into a median lobe. This, in the male, reaches back scarcely one-third the length of the pedicel of the caudal stylets, but in the female about one-half the length of the pedicel. Width of abdomen less than that of any of the thoracic segments, except the first and second, about equal in width to second. Antennulæ shorter than the peduncle of the antennæ; basal segment short, a little curved and having a diameter nearly three times that of the next segment; second segment

longer than the first; third sub-equal to the first. Flagellum equal to the peduncle and consisting of about twelve segments.

First three segments of the antennæ short; fourth as long as the three preceding; fifth as long as the second, third and fourth together; flagellum long, reaching back three-fourths the length of the thorax, and consisting of about seventy-five segments.

Right mandible with a single dentigerous lamella furnished with four obtuse teeth. Left mandible with two dentigerous lamellæ, each with four obtuse teeth Palpus consisting of three segments; the first clavate; the second widest in the middle, its inner margin being straight and its outer formed by two straight lines meeting at an obtuse angle at the middle of the segment; last segment falcate, furnished with numerous plumose hairs along its outer concave margin.

Palpus of maxilliped with five segments. The first very short. The second three times as long as the first and rather broader than long, with the inner margin straight and the outer curved. Third segment short, broadest just above the proximal articulation, becoming narrower distally. Fourth segment clavate and bent inward at the base. Last segment short and only half as wide as the preceding. All the segments provided with scattered hairs along their outer margin and crowded with similar hairs along the inner margin.

Propodus of the first pair of legs in the male ovate, nearly two-thirds as wide as long; the palmar margin slightly convex, armed with a stout conical tooth in the middle, and at the posterior angle with another short obtuse one, surmounting a rough process of the body of the propodus. There are thus really two stout teeth on this margin. Dactylus with its claw reaching beyond the palmar margin, curved strongly, and armed with about fifteen teeth appressed towards the tip.

In the female the first propodus is more slender, being one-half as wide as long. Palmar margin nearly straight and armed with several slender spines, and near the posterior angle with one moderately strong acute tooth. Dactylus long, curved, and armed with about eight teeth longer than those of the male. Dactylus terminating in a claw, which extends beyond the palmar margin.

Anterior genital appendages of the male consisting each of two segments, the first three-fourths the length of the second, sub-quadrate, with four curved spines along the inner margin; the second segment ovate, with an obliquely truncated extremity, which, as well as the adjacent parts of the inner and outer margins, is sparsely cilated. Posterior genital appendages consisting each of a peduncle and two rami. The peduncle about as broad as long, outer margin straight, inner margin approaching the outer distally by a broad curve. Inner ramus navicular, notched at the distal extremity. Outer ramus bi-articulate; first segment triangular; second linguiform, twice as long as broad, with the outer margin and the lower portion of the inner margin furnished with long plumose hairs. Caudal stylets of the male as long as the abdomen; the peduncle a little less than two-thirds as wide as long, expanding distally, where it is excavated for the insertion of the rami. The rami are ovate, moderately acute, width about one-third of the length: the outer ramus about two-thirds as long as the

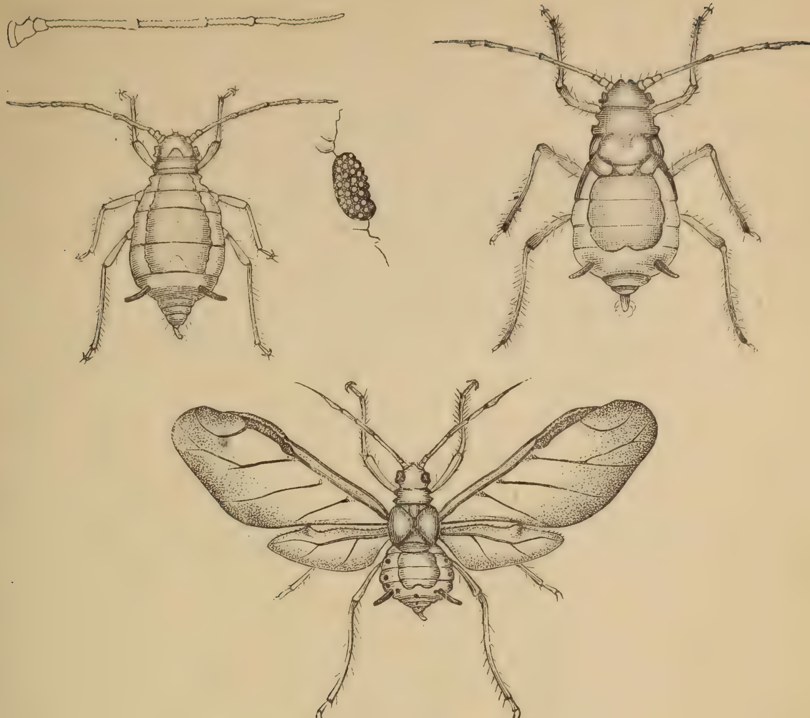
inner, and both tipped with a brush of long hairs, and fringed with numerous setæ: as are also the margins of the peduncle.

Caudal stylets of the female only two-thirds the length of the abdomen, peduncle wider proportionally than in the male, and obtriangular. Rami more lanceolate in outline, scarcely a fourth as wide as long; the outer nearly as long as the inner, which is nearly a third longer than the peduncle.

Found in large numbers in shallow pools of a slow prairie stream, near Abingdon, Knox county, Illinois.

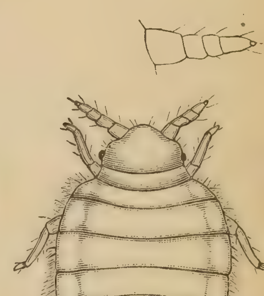
This fine large species is probably nearly related to *Asellus intermedius*, Forbes. It differs, however, from all the forms of this that I have seen, not only in its much greater size, but also in some other important respects. The head is much narrower in the present species than in *intermedius*. The abdomen is narrower in this than the species described by Prof. Forbes, as compared with the width of the thoracic segments. The thoracic segments in specimens of undoubted *intermedius* which I have, increase in width from the first to the last, while in *A. militaris* they are, after the second, of uniform width. The two posterior segments in *A. militaris* are also much more deeply concave along their posterior margin than in the other species mentioned. The propodus in the present species is broader than in *intermedius*, but I have specimens of an *Asellus* from Prof. Forbes, which he provisionally regards as *A. intermedius*, in which the propodus is rather broader than in my species. The genital plates, however, differ much from those of *A. militaris*. The plates, again, are, in *militaris*, almost exactly as in the typical specimens of *intermedius*. The doubtful forms of *intemedius*, however, differ from the present species in the width of head, abdomen, concavity of posterior thoracic segments and in the form of the caudal stylets.

My thanks are due Prof. Forbes for specimens of his two forms of *A. intermedius* and for the use of microscope slides.



Siphonophora coreopsidis. Thos.

Siphonophora acericola. Thos.



Schizoneura panici. Thos.

Bulletin of the Illinois State Laboratory of Natural History.

Vol. I., No. 3.

STUDIES

OF THE

FOOD OF BIRDS, INSECTS, AND FISHES

MADE AT THE

ILLINOIS STATE LABORATORY OF NATURAL HISTORY,

AT

NORMAL, ILLINOIS.

SECOND EDITION.

1903.

The first edition of this bulletin was published at Normal, Illinois, November 1, 1880. It has been out of print for many years, and is lacking in the series of many institutions and correspondents on the regular exchange list of the State Laboratory of Natural History. It is reprinted without change except for the correction of minor clerical and typographical errors.

ON SOME INTERACTIONS OF ORGANISMS.*

By S. A. FORBES.

While the structural relations of living organisms, as expressed in a classification, can best be figured by a tree —the various groups, past and present, being related to each other either as twigs to twigs, as twigs to branches, or as branches to the main stem—yet this illustration does not at all express their *functional* relations. While the anatomical characters of the various groups may show that they are all branches of a common stock, from which they have arisen by repeated divisions and continued divergencies, the history of their lives will show that they are now much more intimately and variously bound together by mutual interactions than are twigs of the same branch—that with respect to their vital activities they occupy rather the relation of organs of the same animal body. If for a type of their classification we look to the vegetable world, for an illustration of their mutual actions and reactions we must look to the animal world. The serious modification of any group, either in numbers, habits, or distribution, must modify, considerably, various other groups; and each of these must transmit the change in turn, or initiate some other form of change, the disturbance thus propagating itself in a far-extending circle.

While the whole organic world, viewed as a living unit, thus differs from the single plant by the much greater in-

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* As details accumulated relating to the food of animals and similar subjects, it was found that a proper discussion of them would necessarily lead, step by step, to a full review of certain parts of the general subject of the reactions between groups of organisms and their surroundings, organic and inorganic. Without such a review, the facts can not be safely generalized, nor the conclusions clearly apprehended to which they point. It has therefore seemed best to prepare the way for the discussion of special subjects by this general discussion of the subject at large.

The practical importance of this larger view is illustrated by the fact that if the current ideas of the value of parasitic and predaceous insects are accepted, we must condemn the bluebird to extermination as a pest; while if the conclusions of this paper are essentially sound, this bird is a very useful species and should be carefully preserved.

terdependence of its parts, on the other hand, it differs from the single animal in the fact that, notwithstanding this intimate and instant sympathy of part with part, it has an immense vitality. To cut off the leg of an animal is often sufficient to destroy its life, but one might cut off the *head* of the animal world, so to speak, without seriously impairing its energy. Suddenly to annihilate every living vertebrate would doubtless set on foot some tremendous revolutions in the life of the earth, but it is certain that in time the wound would heal—that Nature would finish by readjusting her machinery and would then go on much as before. In fact, any subkingdom of animals or any class of plants might thus be struck out, without the slightest danger that terrestrial life would perish as a consequence. The functions of the missing member would be taken on in part by other members, and in part be rendered needless by new adjustments.

We see many present illustrations of this fact, as in Australia, where there is but one native carnivorous animal, and that probably not indigenous; in several Pacific islands where mammals are unknown; and in New Zealand and the Galapagos, where insects are extremely few and the flowers, therefore, chiefly colorless and odorless. We see, likewise, illustrations of the same truth in the conditions of vegetable and animal life in earlier geological periods. Plants and insects, for example, existed together through vast periods of time when there were neither mammals nor birds on earth to supervise or regulate their relations.

If this is true of such immense and revolutionary disturbances, it is all the more certain that this same spontaneous action of natural forces must in time reduce the smaller disturbances of the primitive order caused everywhere by civilized man, and must end by adjusting the whole scheme of organic relations to his interests as completely as to the interests of any other species. It is also plain that if man understands clearly the disorders which arise in the system of Nature as a result of the rapid progressive changes in his own condition and activities, and understands also the processes of Nature which tend to

lessen and remove these disorders, he may, by his own intelligent interference, often avoid or greatly mitigate the evils of his situation, as well as hasten their remedy and removal.

Some general notion of the original order of Nature, which obtains where civilization has not penetrated, will be needful for an understanding of the most important consequences of the modifications of that order which man brings to pass—for an understanding of the relations of our own industrial operations and interests to the general laws and activities of the organic world under whose constant influence we must live and work.

There is a general consent that primeval nature, as in the uninhabited forest or the untilled plain, presents a settled harmony of interaction among organic groups which is in strong contrast with the many serious maladjustments of plants and animals found in countries occupied by man. This is so familiar a fact that I need not dwell upon it, but will cite the reader to the generally accessible "Introduction to Entomology," by Kirby & Spence, for a sufficient statement of it. It will be more to my purpose to discuss the subject from a different standpoint. To determine the primitive order of Nature by induction alone requires such a vast number of observations in all parts of the world, for so long a period of time, that more positive and satisfactory conclusions may perhaps be reached if we call in the aid of first principles, traveling to our end by the *a priori* road.

For the purposes of this inquiry I shall assume as established laws of life, the reality of the struggle for existence, the appearance of variations, and the frequent inheritance of such as conduce to the good of the individual and the species—in short, the evolution of species and higher groups under the influence of natural selection. I shall also postulate, as an accepted law of Nature, the generalization that the species is maintained at the cost of the individual—that, as a general rule, the rate of reproduction is in inverse ratio to the grade of individual development and activity; or, as Spencer tersely states this law, that "Individuation and Genesis are antagonis-

tic." Evidently a species cannot long maintain itself in numbers greater than can find sufficient food, year after year. If it is a phytophagous insect, for example, it will soon dwindle if it seriously lessens the numbers of the plants upon which it feeds, either directly, by eating them up, or indirectly, by so weakening them that they labor under a marked disadvantage in the struggle with other plants for foothold, light, air and food. The interest of the insect is therefore identical with the interest of the plant it feeds upon. Whatever injuriously affects the latter, equally injures the former; and whatever favors the latter, equally favors the former. This must, therefore, be regarded as the extreme normal limit of the numbers of a phytophagous species—a limit such that its depredations shall do no especial harm to the plants upon which it depends for food, but shall remove only the excess of foliage or fruit, or else superfluous individuals which must either perish otherwise, if not eaten, or, surviving, must injure their species by overcrowding. If the plant-feeder multiply beyond the above limit, evidently the diminution of its food supply will soon react to diminish its own numbers; a counter reaction will then take place in favor of the plant, and so on through an oscillation of indefinite continuance.

On the other hand, the reduction of the phytophagous insect below the normal number will evidently injure the food plant by preventing a reduction of its excess of growth or numbers, and will also set up an oscillation like the preceding, except that the steps will be taken in reverse order.*

I next point out the fact that precisely the same reasoning applies to predaceous and parasitic insects. Their interests, also, are identical with the interests of the species they parasitize or prey upon. A diminution of their food reacts to decrease their own numbers. They are thus vitally interested in confining their depredations to the excess of individuals produced, or to redundant or otherwise unessential structures. It is only by a sort of un-

* See "Principles of Biology," by Herbert Spencer, Vol II, pp. 397-478.

lucky accident that a destructive species really injures the species preyed upon.

The discussion has thus far affected only such organisms as are confined to a single species. It remains to see how it applies to such as have several sources of support open to them—such, for instance, as feed indifferently upon several plants or upon a variety of animals, or both. Let us take, first, the case of a predaceous beetle feeding upon a variety of other insects—either indifferently, upon whatever species is most numerous or most accessible, or preferably upon certain species, resorting to others only in case of an insufficiency of its favorite food.

It is at once evident that, taking the group of its food-insects as a unit, the same reasoning applies as if it were restricted to a single species for food; that is, it is interested in the maintenance of these food-species at the highest number consistent with the general conditions of the environment—interested to confine its own depredations to that surplus of its food which would otherwise perish if not eaten—interested, therefore, in establishing a rate of reproduction for itself which will not unduly lessen its food supply. Its interest in the numbers of each species of the group it eats will evidently be the same as its interest in the group as a whole, since the group as a whole can be kept at the highest number possible only by keeping each species at the highest number possible.

If the predatory insect prefer some species of the group to others, we need only say that whatever interest it has in any species of the group, will be an interest in keeping up its numbers to the highest limit; and any failure in this respect will injure it in precisely the ratio of the value of that species as an element of its food. It would be most injured by anything injuriously affecting the species it most preferred—the *preferences* of animals being, according to the doctrine of evolution, like their instincts, inherited tendencies toward the things which have proved beneficial to their progenitors.

This argument holds for birds as well as for insects, for animals of all kinds, in fact, whether their food be simple or mixed, animal or vegetable, or both. It also applies to

parasitic plants. The ideal adjustment is one in which the reproductive rate of each species should be so exactly adapted to its food supply and to the various drains upon it that the species preyed upon should normally produce an excess sufficient for the species it supports. And this statement evidently applies throughout the entire scale of being. Among all orders of plants and animals, the ideal balance of Nature is one promotive of the highest good of all the species. In this ideal state, towards which Nature seems continually striving, every food-producing species of plant or animal would grow and multiply at a rate sufficient to furnish the required amount of food, and every depredating species would reproduce at a rate no higher than just sufficient to appropriate the food thus furnished.

We must now point out how this common interest is naturally subserved—how the mutually beneficial balance between animals and their food is ordinarily maintained.

Exact adjustment is doubtless never reached anywhere even for a single year. It is usually closely approached in primitive nature, but the chances are practically infinite against its becoming really complete, and maladjustment in some degree is therefore the general rule. All species must oscillate more or less. Even the more stable features of the organic environment are too unstable to allow the establishment of any perfectly uniform habit of growth and increase in any species. The most unvarying species will at one time crowd its boundaries vigorously, and at another, sensibly recede from them. That such an oscillation is injurious to a species may be briefly shown. The most favorable condition of a species is that in which its numbers are maintained at the highest possible average limit; and this, as already demonstrated, requires that its food supplies should likewise be maintained at the highest possible limit—that the species should, in fact, confine its appropriations to the unessential surplus of its food. But when the numbers of an oscillating species are above this average limit, it will devour more than this surplus of its food—its food supplies will be directly lessened. On the other hand, when the oscillating species falls below this limit, its food supplies, reacting, of course cannot in-

crease *beyond* the highest possible limit, but will reach it and there stop. The average amount of food will therefore be less than it might be if the species dependent upon it did not oscillate—and, the food being less, the average number of the species itself must be smaller. Our problem is, therefore, to determine how these innumerable small oscillations, due to imperfect adjustment, are usually kept within bounds—to discover the forces and laws which tend to prevent either inordinate increase or decrease of any species, and also those by which widely oscillating species are brought into subjection and reduced to a condition of prosperous uniformity. We may know in general that such laws and forces are constantly at work, and that the tendency of things is towards this healthful equilibrium, because we see substantially such an equilibrium widely established and steadily maintained through long periods of time, notwithstanding the great number and kaleidoscopic variability of the forces by which each species is impressed. But this idea will repay more detailed elucidation. We will notice, first, some of the checks upon injurious oscillations arising out of the laws of the individual organism, and afterwards those which are brought to bear upon it from without.

It will at once be seen that, in any case, the maladjustments possible are of only two kinds—the rate of reproduction in the species must be either relatively too small or relatively too great. If it be relatively too small, if the species bring forth fewer young than could mature, on the average, under existing circumstances, whatever may be the oscillations arising, they will tend to disappear with the disappearance of the species. The average numbers of such a species being, in the most favorable event, less than they might be, it will be at a certain disadvantage in the general struggle for existence—it will eventually yield to some more prolific species with which it comes in competition. If, for any reason, its rate of multiplication be or become too high, the law of the antagonism between individuation and genesis will constantly tend to bring it within the proper limit. Reproduction being more active than is necessary, the individual force and activity will be less than it might be—the species will be at a disad-

vantage in the search for food, and in all its other activities, as compared with other species more exactly adjusted, or, as compared with members of its own species which tend to a better adjustment. As soon as a better-adjusted competitor appears, the other must begin to suffer, and in the long course of evolution will almost certainly disappear. The fact of survival is therefore usually sufficient evidence of a fairly complete adjustment of the rate of production to the drains upon the species.

For the sake of illustration, let us take an instance—and the most difficult we can find for the application of these ideas—the case of a caterpillar and its hymenopterous parasite.

If the rate of increase of the parasite be relatively too great, that is, if more parasites are produced than can find places of deposit for their eggs in the bodies of the mere *excess* of caterpillars, some of them will deposit their eggs in caterpillars which would otherwise come to maturity—that is the number of caterpillars will be gradually diminished. With this diminution of their hosts the parasites will find it more and more difficult favorably to bestow all their eggs, and many of them will fail of development. The multiplication of the parasites will thus be checked, and their numbers will finally become so far reduced that less than the then excess of caterpillars will be infested by them, in which case the caterpillars will commence to increase in numbers, and so on indefinitely. Briefly, the excessive rate of increase of the parasite will keep up an oscillation of numbers in both parasite and host which will cross and recross a certain average line.

Let us now look at the method by which Nature may check this injurious fluctuation.

Let us suppose two groups of a parasitic species at work on the same species of caterpillar, of which one (A) is distinguished by a tendency to an excessive reproductive rate, while the other (B) multiplies no faster than is consistent with the best interest of its host. A, producing more eggs than B, must either parasitize more caterpillars than B, or must deposit a greater number of eggs in each. It cannot parasite more caterpillars than B, be-

cause this would require greater activity—a higher individuation—and this is contrary to the law that individuation and genesis are antagonistic. Instead of being more active than *B*, it will then be less active, and will, therefore, deposit more eggs in each caterpillar. *B*, however, cannot have acquired the habit of depositing too few eggs in each caterpillar, as that would compel it to search habitually for a greater number of larvæ than necessary—to have acquired, that is, a habit of wasting energy—which is, as already said, contrary to evolution. *A* will, therefore, sometimes deposit too many eggs in a caterpillar, and will then either lose the whole deposit, or bring forth a weakened offspring, which will, in the long run, give way to the more vigorous progeny of *B*. This regular production of a wasted excess will constitute an uncompensated drain upon variety *A*, which will end, like any other radical defect, in its yielding to its better-adjusted rival.

Or if, notwithstanding the foregoing, we suppose this excessive reproductive rate to have become fully established, then the parasite-ridden species will evidently labor under such a disadvantage in the struggle for existence that it will probably be crowded out, in time, by some more fortunate rival. If the pair are permanently ill-adjusted, so that permanent loss of numbers follows, they will be treated by the laws of natural selection as a single imperfect animal—they will be pushed to the wall by some better-adjusted caterpillar and parasite, or by some insect free from troublesome companions. We may be sure, therefore, that, as a general rule, in the course of evolution, only those species have been able to survive whose parasites, if any, were not prolific enough sensibly to limit the numbers of their hosts for any length of time.

We notice incidentally that it is thus made unlikely that an injurious species can be exterminated, can even be permanently lessened in numbers, by a parasite strictly dependent upon it—a conclusion which remarkably diminishes the economic rôle of parasitism. The same line of argument will, of course, apply, with slight modifications, to any animal or even to any plant dependent

upon any other animal or any other plant for existence.

From the foregoing argument we conclude that, since the interest of a species of plant or animal and the interest of its "enemies" are identical, and since the operations of natural selection tend constantly to bring about an adjustment of the species and its enemies which shall best promote this common interest, therefore *the annihilation of all the established "enemies" of a species would, as a rule, have no effect to increase its final average numbers.* This being a general law, applying to all organisms, it is plain that the real and final limits of a species are the *inorganic* features of its environment—soil, climate, seasonal peculiarities, and the like.

In treating of the external forces brought to bear upon an oscillating species to restrain its disastrous fluctuations, I shall mention only a part of the organic checks to which it is subject.

It is a general truth, that those animals and plants are least likely to oscillate widely which are preyed upon by the greatest number of species, of the most varied habit. Then the occasional diminution of a single enemy will not greatly affect them, as any consequent excess of their own numbers will be largely cut down by their other enemies, and especially as, in most cases, the backward oscillations of one set of enemies will be neutralized by the forward oscillations of another set. But by the operations of natural selection, most animals are compelled to maintain a varied food habit—so that if one element fails others may be available. Thus each species preyed upon is likely to have a number of enemies, which will assist each other in keeping it properly in check.

Against the uprising of inordinate numbers of insects, commonly harmless but capable of becoming temporarily injurious, the most valuable and reliable protection is undoubtedly afforded by those predaceous birds and insects which eat a *mixed food,* so that in the absence or diminution of any one element of their food, their own numbers are not seriously affected. Resorting, then, to other food supplies, they are found ready, on occasion, for immediate and overwhelming attack against any threatening

foe. Especially does the wonderful locomotive power of birds, enabling them to escape scarcity in one region, which might otherwise decimate them, by simply passing to another more favorable one, without the loss of a life, fit them, above all other animals and agencies, to arrest disorder at the start—to head off aspiring and destructive rebellion before it has had time fairly to make head. But we should not therefrom derive the general, but false and mischievous, notion that the indefinite multiplication of either birds or predaceous insects is good. Too many of either is nearly or quite as harmful as too few.

And this brings us to the application of these principles to the interests of civilized man. We must note how the new forces which he brings into the field expend themselves among those we have been studying, and to what reactions they are in turn subjected. We must first see how far the primitive natural order of life lends itself to the supply of man's needs, to the accomplishment of his purposes; and must determine, in a general way, where he may be content to leave it undisturbed, where he should address himself to its improvement, and where he is compelled to attempt wholly to set it aside, substituting artificial arrangements of his own, devised solely in his own interest.

Some of Nature's arrangements man finds himself unable to improve upon for his own benefit. No one thinks of cultivating the forest to hasten the growth of the wood, or of trimming the wild oak or the maple, or of planting artificially the nuts and acorns in the woods to increase the number of the trees.

We are content to leave things there to go on essentially in the old way, merely anticipating the processes of natural death and decay by removing the trees before they spontaneously perish, and glad if the revolutions of organic life which we set up in the country around do not penetrate to the forest, visiting the leaves and trunks of the trees with the scourge of excessive insect depredations.

Usually, however, we find the ready-made system of Nature less to our liking, and all our cultures are at-

tempts to set it aside more or less completely. In the pasture and meadow, it answers our purpose to substitute other species for the grasses growing there spontaneously, and these adapt themselves easily to the circumstances which have proved favorable to their native predecessors. But in the grain-field and fruit-garden the case is different. Not only do we bring in species often very unlike any aboriginal vegetation and still further altered by long cultivation, but we propose an end quite different from that for whose accomplishment all the arrangements of Nature have been made.

According to the settled order, the whole economy of every fully-established plant and animal is directed to the production of one more plant or animal to take the place of the first one when it perishes. All the excess of growth and reproduction is a reward to friends or a tribute to powerful enemies, intended to make only this one end secure. But man is not content with this. He does not raise apple-trees for the sake of raising more apple-trees. He would cut off all excess not useful to himself, and all that is useful he would stimulate to the utmost, and appropriate to his own benefit. In carrying out this purpose he finds himself opposed and harassed at every step by rules and customs of the natural world established long ages before he was seen upon the earth—laws certainly too powerful for him wholly to defy, customs too deeply rooted for him to overturn without the most complicated consequences. And yet even here, we see that the primitive order is not an evil, it is simply insufficient. It is good as far as it goes, and must be carefully respected in its essence, however far it may be modified in detail. We find abundant reason for a belief in its usual beneficence and for a reluctance to disturb it without urgent necessity.

At the best the disturbances we must originate will be tremendous. Old combinations will necessarily be broken up and new ones entered into. As in a country undergoing a radical change in its form of government, disorders will almost certainly break out—some of them fearfully destructive and temporarily uncontrollable; but the general tendency towards a just equilibrium will make itself

felt, and intelligent effort will mitigate some evils and avoid others. Without attempting to go into deatils—which would be quite unnecessary for my purpose—I will endeavor briefly to show the bearing of some of these ideas upon practical conduct.

To man, as to nature at large, the question of adjustment is of vast importance, since the eminently destructive species are the widely oscillating ones. Those insects which are well adjusted to their environments, organic and inorganic, are either harmless or inflict but moderate injury (our ordinary crickets and grasshoppers are examples); while those that are imperfectly adjusted, whose numbers are, therefore, subject to wide fluctuations, like the Colorado grasshopper, the chinch-bug and the army-worm, are the enemies which we have reason to dread. Man should then especially address his efforts, first, to prevent any unnecessary disturbance of the settled order of the life of his region which will convert relatively stationary species into widely oscillating ones; second, to destroy or render stationary all the oscillating species injurious to him; or, failing in this, to restrict their oscillations within the narrowest limits possible.

For example, remembering that every species oscillates to some extent, and is held to relatively constant numbers by the joint action of several restraining forces, we see that the removal or weakening of any check or barrier is sufficient to widen and intensify this dangerous oscillation; may even convert a perfectly harmless species into a frightful pest. Witness the maple bark-louse, which is so rare in natural forests as scarcely ever to be seen, limited there as it is by its feeble locomotive power and the scattered situation of the trees it infests. With the multiplication and concentration of its food in towns, it has increased enormously, and if it has not done the gravest injury it is because the trees attacked by it are of comparatively slight economic value, and because it has finally reached new limits which hem it in once more.

We are therefore sure that the destruction of any species of insectivorous bird or predaceous insect is a thing to be done, if at all, only after the fullest acquaintance

with the facts. The natural presumptions are nearly all in their favor. It is also certain that the species best worth preserving are the mixed feeders and not those of narrowly restricted dietary (parasites, for instance)—that while the destruction of the latter would cause injurious oscillations in the species affected by them, they afford a very uncertain safeguard against the *rise* of such oscillations. In fact, their undue increase would be finally as dangerous as their diminution.

Notwithstanding the strong presumption in favor of the natural system, when we remember that the purposes of man and what, for convenience's sake, we may call the purposes of Nature do not fully harmonize, we find it incredible that, acting intelligently, we should not be able to modify existing arrangements to our advantage—especially since much of the progress of the race is due to such modifications made in the past.

We should observe, in passing, that the principal general problem of economic biology is that of the discovery of the laws of oscillation in plants and animals, and of the methods of Nature for its prevention and control.

For all this, evidently, the first, indispensable requisite is a *thorough knowledge of the natural order*—an *intelligently conducted natural history survey.* Without the general knowledge which such a survey would give us, all our measures must be empirical, temporary, uncertain, and often dangerous.

Next we must know the nature, extent, and most important consequences of the disturbances of this order necessarily resulting from human interference—we must study the methods by which Nature reduces these disturbances, and learn how to second her efforts to our own best advantage.

But far the most important general conclusion we have reached is a conviction of the general beneficence of Nature, a profound respect for the natural order, a belief that the part of wisdom is essentially that of practical conservatism in dealing with the system of things by which we are surrounded.

Summary.

The argument and conclusions of this paper may be thus briefly recapitulated:—

We find a mutual interdependence of organic groups and a modifiability of their habits, numbers, and distribution which brings them under the control of man. We also see that, after the most violent disturbances of their internal relations, a favorable readjustment eventually occurs. Starting with the general laws of multiplication and natural selection, it is first observed that every species of plant or animal dependent upon living organic food is interested to establish such a rate of reproduction as will, first, meet all the drains to which it is itself subjected, and still leave a sufficient progeny to maintain its own numbers, and, second, leave a sufficient supply of its own food-species to keep them undiminished, year after year. That is, we find that the interests of any destructive plant or animal are identical with the interests of its food supply.

This common interest of the organism and its organic food is continually promoted by natural selection, by which those that unduly weaken the sources of their own support are eventually crowded out by others with a better-adjusted rate of increase; but, because of the immense number, variability, and complexity of the forces involved, a complete adjustment is never reached. Whether the rate of multiplication of the food-producing species be relatively too great or relatively too small, the result is to cause an oscillation of numbers of both depredating species and its food. These oscillations of a species are both directly and indirectly injurious to it, and tend, in various ways, to diminish the average of its numbers, especially by lessening the general average amount of the food available for it. By the operations of natural selection, therefore, widely oscillating species, thus placed at a marked disadvantage as compared with more stable ones, are either eliminated, or else reduced to order more or less completely. They tend to become so adjusted to their food supplies as to appropriate only their surplus and excess.

Hence, as a general thing, the real limits of a species are not set by its organic environment, but by the inorganic; and the removal of the organic checks upon a species would not finally diminish its average numbers.

Among the external checks upon the oscillations of species of insects, the most important are those predaceous insects and insectivorous birds which eat a varied food, using most freely those elements of their dietary which are, for the time being, most abundant.

When we compare the results of the primitive natural order with the interests of man, we see that, with much coincidence, there is also considerable conflict. While the natural order is directed to the mere maintenance of the species, the necessities of a man usually require much more. They require that the plant or animal should be urged to excessive and superfluous growth and increase, and that all the surplus, variously and widely distributed in nature, should now be appropriated to the supply of human wants. From the consequent human interferences with the established system of things, numerous disturbance arise—many of them full of danger, others fruitful of positive evil. Oscillations of species appear, not less injurious to man than to the plants and animals more directly involved. Indeed, most of the serious insect injuries, for example, are due to species whose injurious oscillations have resulted from changes of the organic balance initiated by man.

To avoid or mitigate the evils likely to arise, and to adapt the life of his region more exactly to his purposes, man must study the natural order as a whole, and must understand the disturbances to which it has been subject. Especially he must know the forces which tend to the reduction of these disturbances and those which tend to perpetuate or aggravate them, in order that he may reinforce the first and weaken or divert the second.

The main lesson of conduct taught us by these facts and reasonings is that of conservative action and exhaustive inquiry. Reasoning unwarranted by facts, and facts not correctly and sufficiently reasoned out, are equally worthless and dangerous for practical use.

THE FOOD OF FISHES.

By S. A. FORBES.

For a clear conception of the general and intricate interdependence of the different forms of organic life upon the earth, one cannot do better than to study thoroughly the life of a permanent body of fresh water—a river or smaller stream, or, better than these, a lake. The animals of such a body of water are, as a whole, curiously *isolated* —closely related among themselves in all their interests, but so far independent of the life of the land about them that if every terrestrial plant and animal were annihilated it would doubtless be long before the general multitude of the inhabitants of the lake or stream would feel the effects of this event in any very important way.

Further, the greater difficulty of communication between the different parts of a water system as compared with the different regions of the land, is such that the former are much the more sharply limited. There is very much less interchange of all kinds between two branches of the same stream, for example, than between the tracts of land which they separate. Consequently, one finds in a single body of water a far more complete and independent equilibrium of organic life and activity than in any equal body of land. It forms a little world within itself—a microcosm within which all the elemental forces are at work and the play of life goes on in full, but on so small a scale as to bring it easily within the mental grasp.

Nowhere can one see more clearly illustrated what may be called the *sensibility* of such an organic complex—expressed by the fact that whatever affects any species belonging to it, must speedily have its influence of some sort upon the whole assemblage. He will thus be made to see the impossibility of studying any form successfully out of relation to the other forms—the necessity for taking a comprehensive survey of the whole as a condition to a satisfactory understanding of any part. If one wishes to be-

come acquainted with the black bass, for example, he will learn but little if he limits himself to that species. He must evidently study also the species upon which it depends for its existence, and the various conditions upon which *these* depend. He must likewise study the species with which it comes in competition, and the entire system of conditions affecting their prosperity. Leaving out any of these, he is like one who undertakes to make out the construction of a watch, but overlooks one wheel; and by the time he has studied all these sufficiently, he will find that he has run through the whole complicated mechanism of the aquatic life of the locality, both animal and vegetable, of which his species forms but a single element.*

In such a general survey of the plants and animals of a region, the study of their food relations will be found to afford an admirable objective point. Doubtless, of all the features of the environment of an individual, none affect it at the same time so powerfully, so variously and so intimately as the elements of its food. Even climate, season, soil and the inorganic circumstances generally, influence an animal through its food quite as much as by their direct action. It is through the food relation that animals touch each other and the surrounding world at the greatest number of points, here they crowd upon each other the most closely, at this point the struggle for existence becomes sharpest and most deadly; and, finally, it is through the food relation almost entirely that animals are brought in contact with the material interests of man. Both for the student of science and for the economist, therefore, we find this subject of peculiar interest and value. It includes many of the most important relations

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* I cannot too strongly emphasize the fact—frequently illustrated, I venture to hope, by the papers of this series—that a comprehensive survey of our entire natural history is absolutely essential to a good *working knowledge* of those parts of it which chiefly attract popular attention, —that is, its edible fishes, its injurious and beneficial insects, and its parasitic plants. Such a survey, however, should not stop with a study of the dead forms of Nature, ending in mere lists and descriptions. To have an *applicable* value, it must treat the life of the region as an organic unit, must study it *in action*, and direct principal attention to the laws of its activity.

of a species, and may properly be made the nucleus about which all the facts of its natural history are gathered.

In a paper on the food of Illinois fishes published in the second bulletin of this Laboratory, the subject was treated in a general and cursory way, the amount of material upon which that paper was based being insufficient for exact or detailed description. The favor with which that preliminary notice was received, has made it possible to undertake a more serious investigation; and this paper contains an account of the food of the Acanthopteri of the State which I believe to be nearly or quite sufficient for the student of science and for the practical fish-culturist. It is still necessary only to study the food of specimens under a half-inch length, and to test the value of the general conclusions here reached, by occasional examinations of fishes taken from other waters at other seasons of the year. Among the results of this study, those relating to the food of the young are especially worthy of attention, and these have therefore been summed up separately.

The explanation of certain structural conditions about the mouth, throat and gills, has proceeded so far as to make it very likely that a number of definite general correspondences between structure and food will be made out, which will enable us to tell with considerable accuracy and detail what the food of an unknown fish must be, by a mere inspection of the fish itself; provided, of course, that we know what food is accessible to it in its habitat. It seems likely to prove to be a general rule that a fish makes scarcely more than a *mechanical* selection from the articles of food accessible to it, taking almost indifferently whatever edible things the water contains which its habitual range and its peculiar alimentary apparatus enable it to appropriate, and eating of these in about the ratio of their relative abundance and the ease with which they can be appropriated at any time and place. If this is so, knowing the structure of a fish and the contents of a body of water, we shall be able to tell, *a priori,* what the fish will eat if placed therein.

This is, in fact, the objective point of the present investigation—to arrive at a knowledge of the correlations of

structure and food habits sufficiently detailed and exact to make the tedious and difficult labor of examining the contents of stomachs unnecessary hereafter. Some generalizations of this sort are given in the following pages, and others relate to genera not included in this report.

The method of this paper differs from that of the previous one referred to by the calculation of the *ratios* of the different kinds of food for each species or group of individuals. These ratios were obtained by averaging careful estimates of the relative amounts of the different food elements found in each stomach.

It is proposed to follow a similar method hereafter down through the remaining orders of the class. Most of the material has been collected for this purpose, and much of it has been already studied.

Order TELEOCEPHALI.

Suborder ACANTHOPTERI.

This suborder includes all Illinois fishes which have the anterior dorsal fin (where there are two) or the first rays of the dorsal (where there is but one) stiff, spinous, and sharp, and united by an evident membrane; excepting only the remarkable "brook silversides," which is placed by Drs. Gill and Jordan in another group. It embraces all our game fishes except those belonging to the pickerel family (*Esocidæ*) and the salmon family (*Salmonidæ*). Its principal members are the darters, the various species of perch and bass, the sunfishes, and the sheepshead. Forty-six species of the order have been collected in the State, but only thirty-four of these are common enough to form features of any importance in our fish fauna.

The most numerous family of the group is the *Centrarchidæ* (sunfishes); the most important species are the two kinds of black bass, the pike-perch or "wall-eyed pike,"*

* It is generally to be desired that the absurd names of "Salmon" and "Jack Salmon" for these species should be suppressed. They might as well be called suckers or catfishes or minnows, as far as accuracy is concerned. Common names are many times harder to kill than the cat of the proverb, however; and it is probable that unnumbered generations will continue to call the pike-perch "salmon"; the sunfishes, "perch"; and the black bass, "trout."

the common perch, the white bass, and the croppie or silver bass.

The following account of the food of this suborder is based upon the careful microscopic study of the contents of four hundred and twenty-five stomachs, representing six families, twenty genera* and thirty-three species.

These were all collected by myself or one of my assistants (Mr. W. H. Garman), and labeled at the time with name of species, locality, and date. While the northern half of the State is most fully represented, several trips to southern Illinois contributed to the material studied and it is believed that the results arrived at are substantially true for our whole area.

Family ETHEOSTOMATIDAE. The Darters.

What the humming-birds are in our avifauna, the "darters" are among our fresh-water fishes. Minute, agile, beautiful, delighting in the clear, swift waters of rocky streams, no group of fishes is more interesting to the collector; and in the present state of their classification, none will better repay his study. Notwithstanding their trivial size, they do not seem to be *dwarfed* so much as *concentrated* fishes—each carrying in its little body all the activity, spirit, grace, complexity of detail, and perfection of finish to be found in a perch or a "wall-eyed pike."

They are generally distributed, in suitable streams throughout the State; but we have found them much the most abundant in northern Illinois—in the upper Galena River, in Yellow Creek near Freeport, and in tributaries of the Kishwaukee at Belvidere.

A short and strong minnow-seine of very fine mesh is needed in collecting them. Rapid hauls, made almost on the run, down stream, in swift and shallow water, will be found the most successful. Two or three species, of wider range, will be taken in ordinary situations, in collecting for minnows generally: but the brightest and most characteristic forms can only be got by special effort.†

* The classification of this paper is substantially that of Jordan's Manual of the Vertebrates of North America, etc., Ed. 2, 1878.

† For a very entertaining and instructive account of these fishes, the reader is referred to papers in the American Naturalist, by Messrs. Jordan and Copeland, Vol. X, pp. 335-341, and Vol. XI, pp. 86-88.

I shall give here a description of the food of the family, based upon a study of the contents of seventy stomachs representing fifteen species, collected in all parts of Illinois, in several months of four successive years. These indicate much more than their number would imply, since from those collected at each time and place, as many were commonly studied as were necessary to give a full idea of the food of the species then and there. The different individuals from the same date and locality usually agreed so closely in food, that the study of from two to five gave all the facts obtainable from several times as many. The data here given, therefore, really exhibit the food of the family at different seasons in twenty-nine localities within the State.

The genus *Pleurolepis* is comparatively rare in Illinois as there are few of the sandy streams in the State, which it inhabits. Seven individuals were examined—four of *P. pellucidus* and three of *P. asprellus*. The food of these specimens was remarkably uniform—the only elements found being the larvæ of small Diptera and ephemerids. Eighty-one per cent. of the food of all consisted of the larvæ of Chironomus*—a small, gnat-like insect—twelve per cent. of the larvæ of other small Diptera, and the remaining seven per cent. of ephemerid larvæ (May-flies).

Twelve specimens of the genus *Alvordius* were studied —seven of *maculatus* and five of *phoxocephalus*. These represented five different localities and dates. This is a larger species than the preceding, and to this fact is probably due the predominance (seventy-five per cent.) in its food of the larvæ and pupæ of May-flies (Ephemeridæ). These included four per cent. of the larvæ of *Palingenia bilineata*, Say, one of the largest ephemerids in our streams. The remaining kinds were larvæ of dragonflies (Agrionidæ), four per cent., larvæ of Chironomus, seven per cent., *Corixa tumida*, Uhl., thirteen per cent., and Cyclops, one per cent.

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* The larvæ of Chironomus are among the most important elements of fish food in our waters, appearing in abundance in the stomachs of the young of a great variety of species. They have been too little studied in this country to allow specific determination.

The genus Boleosoma, regarded by Dr. Jordan as the typical darter, was represented by twelve specimens from eight localities—nine of *maculatum,* two of *olmstedi* and one of *camurum.** These specimens show but slight food differences from other darters of similar size, the only notable variation being the appearance of fifteen per cent. of case-worms (larvæ of Phryganeidæ). Sixty-six per cent. of the food was Chironomus larvæ, seven per cent. larvæ of other minute Diptera, and the remaining twelve per cent. was larvæ of small ephemerids, and a few Cyclops.

I studied the food of two specimens of *Pœcilichthys variatus,* four of *P. spectabilis,* and two of *P. asprigenis* —making eight of the genus, representing six localities. Fifty-eight per cent. of small larvæ of Diptera (forty-nine per cent. of Chironomus), thirty-two per cent. of larvæ and pupæ of small ephemerids, and ten per cent. of case-worms made up the entire bill of fare.

Percina caprodes, the largest of the group, departs from all the foregoing species by the prominence given to crustacean food—thirty per cent. of Entomostraca and three per cent. of the smallest of our Amphipoda, *Allorchestes dentata* (Smith), Faxon. Most of the Entomostraca were Cladocera, including Daphnia, Eurycercus, and Daphnella.†

Here occurred the only instance of molluscan food in the group. One specimen had taken a few individuals of *Ancylus rivularis,* Say. Reduced ratios of Chironomus and ephemerid larvæ, and a few *Corixa tumida* complete the list.

Of *Nanostoma zonale,* less common than the others, but two individuals were examined, and these had eaten nothing but larvæ of small Diptera, including sixty-five per cent. of Chironomus.

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* *Boleosoma maculatum* and *B. olmstedi* should undoubtedly be united. Specimens in the laboratory collection present the extremes of both forms, together with numerous intermediate stages of each character used to distinguish them.

This whole group exhibits a surprising variability, perhaps due to its comparatively recent origin.

† Daphnella was found in a Percina from the Calumet River, at South Chicago, but not in condition to permit the determination of the species.

Six specimens of *Etheostoma flabellare* var. *lineolata,* from four localities, had eaten sixty-one per cent. of Chironomus larvæ, twenty-seven per cent. larvæ of small ephemerids, and twelve per cent. of Copepoda (Cyclops).

Boleichthys elegans, found only in the southern part of the State (three specimens examined), had eaten only dipterous larvæ (thirty-seven per cent.) and ephemerid larvæ (sixty-three per cent.). This is a larger, heavier species than most of the others, and, therefore, like Alvordius, prefers ephemerids to gnats.

Last and least comes *Microperca punctulata,* represented by nine specimens from four localities in northern Illinois. This smallest of the darters shares with Percina, the largest, the peculiarity of a large ratio of crustacean food, which made up sixty-four per cent. of the total. The principal kinds were Cyclops, Chydorus, young *Gammarus fasciatus,* Say, and young *Crangonyx gracilis,* Smith. The remaining elements were Chironomus larvæ (thirty-four per cent.) and a trace of ephemerids (two per cent.).

It will be seen that the family, taken as a whole, divides into two sections, distinguished by the abundance or deficiency of crustacean food. This is easily explained by the fact that Percina and Microperca range much more freely than the other genera, being frequently found among weeds and algæ in comparatively slow water with muddy bottom, while the others are rather closely confined to swift and rocky shallows.

In discussing the food of the whole group, taken as a unit, it may best be compared with the food of the young of other percoids. It is thus seen to be remarkable for the predominance of the larvæ of Chironomus and small Ephemeridæ—the former of these comprising forty-four per cent. and the latter twenty-three per cent. of the whole food of the seventy specimens. In young black bass (*Micropterus pallidus*), on the other hand, the averages of nine specimens, ranging from five-eighths inch to one and a half inches in length, were, in general terms as follows: Cladocera forty-two per cent., Copepoda seven per cent., young fishes twenty per cent., Corixa and young

Notonecta twenty-nine per cent., and larval Chironomus only two per cent. The search for the cause of this difference leads naturally to an examination of the whole economy of these little fishes, and opens up the question of their origin as a group.

The close relation of the Etheostomatidæ to the Percidæ requires us to believe that the two groups have but recently diverged, if, indeed, they are yet distinctly separate.

We must inquire, therefore, into the causes which have operated upon a group of percoids to limit their range to such apparently unfavorable situations, to diminish their size, to develop unduly the paired fins and reduce the air-bladder, to remove the scales of several species more or less completely from the head, breast, neck, and ventral region, and to restrict their food chiefly to the few forms mentioned above.

No species can long maintain itself anywhere which cannot, in some way, find a sufficient supply of food, and also protect itself against its enemies. In the contest with its enemies it may acquire defensive structures or powers of escape sufficient for its protection, or a reproductive capacity which will compensate for large losses, or it may become adapted to some place of refuge where other fishes will not follow. What better refuge could a harassed fish desire than the hiding-places among stones in the shallows of a stream, where the water dashes ceaslessly by with a swiftness few fish can stem? And if, at the same time, the refugee develops a swimming power which enables it to dart like a flash against the strongest current, its safety would seem to be insured. But what food could it find in such a place? Let us turn over the stones in such a stream, sweeping the roiled water at the same time with a small cloth net, and we shall find larvæ of Chironomus and small ephemerids and other such prey, and little else —food too minute and difficult of access to support a large fish, but answering very well if our immigrant *can keep down his size.* Here the principles of natural selection assert their power. The limited supply of food early arrests the growth of the young; while every fish which passes the allowable maximum is forced for food to brave

the dangers of the deeper waters, where the chances are that it falls a prey. On the other hand, the smaller the size of those which escape this alternative, the less likely will they be to attract the appetite of the small gar or other guerilla which may occasionally raid their retreat, and the more easily will they slip about under stones in search of their microscopic game.*

Like other fishes, the darters must have their periods of repose, all the more urgent because of the constant struggle with the swift current which their habitat imposes. Shut out from the deep, still pools and slow eddies where the larger species lurk, they are forced to spend their leisure on or beneath the bottom of the stream, resting on their extended pectorals and anal, or wholly buried in the sand. Possibly this fact is correlated with the absence or rudimentary condition of the air-bladder; as it is a rule with many exceptions—but still, probably, a rule—that this organ is wanting in fishes which live chiefly at the bottom.

Doubtless the search for food has much to do with this selection of a habitat. I have found that the young of nearly all species of our fresh-water fishes are competitors for food, feeding almost entirely on Entomostraca and the larvæ of minute Diptera.† As a tree sends out its roots in all directions in search of nourishment, so each of the larger divisions of animals extends its various groups into every place where available food occurs, each group becoming adapted to the special features of its situation. Given this supply of certain kinds of food, nearly inaccessible to the ordinary fish, it is to be expected that some fishes would become especially fitted to its utilization. Thus the Etheostomatidæ as a group are explained, in a word, by the hypothesis of the progressive adaptation of the young of certain Percidæ to a peculiar place of refuge and a peculiarly situated food supply.

Perhaps we may, without violence, call these the mountaineers among fishes. Forced from the populous and fertile valleys of the river beds and lake bottoms, they have

* In Boleosoma, which is normally scaled in front of the dorsal fin, we often find the skin of this region bare in large specimens, and showing evident signs of rubbing.

† Several of the Catostomidæ (suckers) are an exception to this rule, feeding when young chiefly on algæ and Protozoa.

taken refuge from their enemies in the rocky highlands where the free waters play in ceaseless torrents, and there they have wrested from stubborn nature a meager living. Although diminished in size by their continual struggle with the elements, they have developed an activity and hardihood, a vigor of life and glow of high color almost unknown among the easier livers of the lower lands.

The following table (see page 30) will facilitate a comparison of the records of the different genera. The percentages were obtained by estimating carefully the ratios of each element of the food of each individual, and averaging these ratios for all the individuals of a species.

Family PERCIDÆ. The Perches.

This family consists, in this State, of three species—the common yellow perch and the two species of pike-perch or "wall-eyed pike." I have examined the food of seventy-five specimens of this family, so distributed in time and space as to give a satisfactory idea of the usual food.

PERCA AMERICANA, Schrank. THE COMMON PERCH. RINGED PERCH.

This exceedingly well-known species is most abundant along the shores of Lake Michigan and in the small streams and lakes of the northeastern part of the State, becoming less common to the south and west. In the Illinois River at Peoria and Henry it occurs in limited numbers, but in southern Illinois disappears so completely that even its name (there generally pronounced "pearch") is transferred to a different family, the sunfishes (Centrarchidæ).

My knowledge of the food of this species is derived from the study of the contents of forty-nine stomachs, of which thirty were from adults and the remaining nineteen from fishes ranging from 13/16 inch to four inches in length. Ten localities and as many dates are represented by these specimens. Some were taken in the Illinois River, others in Lake Michigan and its southern tributaries, and still others in Fox R. at McHenry, and in the lakes connected with that stream. One lot included

DETAILS OF THE FOOD OF THE ETHEOSTOMATIDÆ.

	Pleurolepis.	Alvordius.	Boleosoma.	Pœcilichthys.	Percina.	Nanostoma.	Etheostoma.	Boleichthys.	Microperca.
Number of specimens	7	12	12	8	11	2	6	3	9
I. MOLLUSCA	....	....	....	....	01	....	....	....	....
Ancylus rivularis Say	....	....	....	....	01	....	....	....	....
II. INSECTA	100	99	96	100	65	100	88	100	36
1. *Diptera*	93	07	73	58	43	100	61	37	34
Undetermined larvæ.	12	01	07	09	02	35	....	10	....
Chironomus larvæ ..	81	06	66	49	41	65	61	27	34
2. *Hemiptera*	....	13	....	....	05	....	....	....	....
Corixa	....	13	....	....	05	....	....	....	....
Undetermined	....	....	....	....	03	....	....	....	....
Larvæ	....	07	....	....	02	....	....	....	....
C. tumida Uhl.....	....	06	....	....	....	....	....	....	....
3. *Neuroptera*	07	79	23	42	17	....	27	63	02
Ephemeridæ.........	07	75	08	32	09	....	27	63	02
Pupæ	....	08	....	14	....	....	....	....	....
Larvæ	07	63	08	18	09	....	27	63	02
Palingenia	....	04	....	....	....	....	....	....	....
Agrionidæ (pupæ) ..	....	04	....	....	....	....	....	....	....
Phryganeidæ (larvæ)	....	....	15	10	08	....	....	....	....
III. CRUSTACEA...	....	01	04	....	33	....	12	....	64
1. *Amphipoda*	....	....	....	....	03	....	....	....	12
Gammarus, yg.......	....	....	....	....	....	....	....	....	06
Crangonyx "	....	....	....	....	....	....	....	....	06
Allorchestes dentata Sm.	....	....	....	....	03	....	....	....	....
2. *Cladocera*.............	....	....	....	....	24	....	....	....	27
Undetermined........	....	....	....	....	05	....	....	....	....
Daphniidæ	....	....	....	....	06	....	....	....	....
Daphnia...........	....	....	....	....	07	....	....	....	....
Sididæ	....	....	....	....	05	....	....	....	....
Daphnella.........	....	....	....	....	05	....	....	....	....
Lynceidæ...........	....	....	....	....	01	....	....	....	03
Chydorus	....	....	....	....	....	....	....	....	24
Eurycercus........	....	....	....	....	01	....	....	....	....
3. *Ostracoda*.............	....	....	....	....	01	...	....	....	....
Cyprididæ	....	....	....	....	01	....	....	....	06
Undetermined	....	....	....	....	01	....	....	....	06
Cypris	....	....	....	....	....	....	....	....	...
4. *Copepoda*	....	01	44	....	05	...	12	....	19
Cyclops	....	01	04	....	05	....	12	....	19
Confervoid Algæ...........	....	....	....	....	01	....	....	....	....

in these notes was bought in the Chicago market. They were evidently of the river form of the species, and judging from the contents of their stomachs, which included a crustacean* not known to occur in Illinois but found abundantly in Michigan, I conclude that they were from that state or from Wisconsin.

* *Mancasellus tenax*, Harger.

Food of the Young.

Finding that the food of most fishes differs with age, I have grouped the young according to size, and averaged the food for each group separately—the first group consisting usually of those under an inch in length, the second of those from one to two, etc.

Two perch under an inch in length had eaten nothing but Entomostraca—about equal quantities of Cyclops and Daphnias. It was not until the specimens reached an inch and a half in length that insects of any considerable size appeared in the food. A single smaller fish had eaten a few minute larvæ of Chironomus, but otherwise the food at this age consisted wholly of Entomostraca.

About thirty-four per cent. of the food of nine specimens ranging from $1\frac{1}{8}$ to two inches in length consisted of insects, and sixty-six per cent. of crustaceans. The only insects recognized were the larvæ and pupæ of Chironomus (eleven per cent.), small water-bugs—*Corixa tumida,* Uhl., *C. alternata,* Say, etc. (twenty-three per cent.)—and a trace of larvæ of May-flies (Ephemeridæ). The Crustacea were chiefly Cladocera and Copepoda—thirty-six per cent. and twenty-four per cent. respectively. Four of the nine had eaten small quantities of a small amphipod crustacean, *Allorchestes dentata,* which is very abundant north, and has, in fact, about the same distribution in the State as the perch itself. The Cladocera were chiefly Daphniidæ (twenty-seven per cent.), including *Daphnia pulex,* L., *Simocephalus americanus,* Birge, and *Bosmina longirostris.* Specimens of Chydorus and Pleuroxus made up the principal part of the nine per cent. of Lynceidæ eaten. The Copepoda were all Cyclops and Diaptomus.

Four specimens two and a half inches long, all taken at Peoria in November, 1878, had eaten nothing but Hemiptera (twelve per cent.) and Neuroptera (eighty-eight per cent.). The Hemiptera were all *Corixa alternata,* and the Neuroptera were nearly all the extremely common larva of one of our most abundant May-flies (*Palingenia bilineata,* Say). Larvæ of small dragon-flies (Agrionini) made five per cent. of the food. The simplicity of the

food of these specimens is probably due partly to the fact that they were all caught at the same time and place, and partly to the wintry weather when they were taken.

Four specimens, from three and a half to four inches long, representing two localities and dates, had eaten a greater variety of articles, the food, in fact, now closely approaching that of the adult. Forty-five per cent. of the food was insects—chiefly larvæ of May-flies—and fifty-five per cent. Crustacea—chiefly Amphipoda and Cladocera. Other insect elements were larvæ of Chironomus, six per cent., and four per cent. of Corixas. The Cladocera were all Daphnia, and the Amphipoda were *Allorchestes dentata.* A single specimen from Long L., near Pekin, Ill., had eaten an isopod crustacean (Asellus). Cyprididæ, another family of minute crustaceans, formed eight per cent. of the whole food of these specimens.

Food of the Adult.

The thirty mature individuals may best be treated in two groups, the first from streams and the second from Lake Michigan.

Four of the first group were bought in the Chicago market, in March, 1880; six were taken from the upper Fox, in May; four were from Calumet R. at South Chicago, taken in August, 1878, and four were caught in October of that year, from the Illinois at Peoria.

We notice, first, the entire disappearance of Entomostraca, which are thus seen to be food proper to the young. We next observe the appearance of Mollusca (nineteen per cent.), which are evidently no insignificant food resource of the species. Unio, Cyclas, Succinea, *Physa heterostropha,* Say, and *Valvata tricarinata,* Say, are the mollusks recognized. Notwithstanding the lack of Entomostraca, Crustacea are the most important resource of these river specimens, constituting forty-eight per cent. of their food. Crawfishes (Cambarus) and our common little fresh-water shrimp (*Palæmonetes exilipes,* St.) compose ten per cent. of the whole; the previously noticed Allorchestes amounts to fifteen per cent.; and species of Asellus, and *Mancasellus tenax* to twenty-three per cent. The Mancacelli were all from the specimens

from the Chicago market. Insects are also an important item—amounting to twenty-four per cent., nearly all being the larvæ of Neuroptera—Mayflies (Ephemeridæ), dragon-flies and case-flies (Phryganeidæ). A single specimen from Peoria Lake had eaten one small fish—a "darter" of the genus Pœcilichthys.

The second group, twelve specimens from Lake Michigan, presents a curious and instructive contrast in food to the foregoing. Mollusks and insects wholly disappear, and Crustacea are limited to the commonest crawfish of the lakes (*Cambarus virilis,* Hagen), which forms fourteen per cent. of the food. The remaining eighty-six per cent. consisted wholly of fishes, all minnows (Cyprinidæ) so far as recognized except one, and that was some undetermined percoid—probably itself a perch.

It will thus be seen that the common perch has a food history of three periods—the periods of infancy, youth, and mature age. In the first it lives wholly on Entomostraca and the minutest larvæ of Diptera; in the second, commencing when the fish is about an inch and a half in length, it takes up first the smaller and then the larger kinds of aquatic insects in gradually increasing ratio, the entomostracan food at the same time diminishing in importance; and in the third it appropriates, in addition, mollusks, crawfishes and fishes—in the lake specimens depending almost wholly on the last two elements.

We have here the first instance of a fact which we shall see again and again illustrated—that the young, having at first an alimentary apparatus too small and delicate to dispose of any insects but the minutest larvæ, live almost wholly on minute crustaceans.

It is proper to note that the lake and river perch are by some good authorities regarded as separate species—the latter being much more highly colored than the former. I have not found so strict a separation of the two forms as that described by Mr. E. W. Nelson, but have frequently taken both in the same haul of the seine in different parts of Calumet R. and in Lake George, Ind.—a body of water communicating with Lake Michigan by an outlet three or four miles long. Occasional pale specimens are also taken far from the lakes, in the Fox and Illinois rivers. The

difference in color is probably due partly to the smaller amount of light to which those inhabiting the deeper waters of the lake are exposed, and partly to their piscivorous habit combined with the comparatively few lurking places afforded them. There is some evidence that fish food bleaches a fish directly, and a good deal that it does so indirectly, by increasing the importance of an inconspicuous appearance.

STIZOSTETHIUM CANADENSE, Smith. GRAY PIKE-PERCH. SAUGER. "JACK-SALMON."

Fourteen specimens of this excellent fish were examined, all of which were from the Illinois R., ten taken in October, 1878, one in June, 1877, and three in November, 1877. It is evidently a very destructive species. These specimens had eaten nothing but fishes. In three cases these were unrecognizable, and in two others I could only tell that they were Acanthopteri. Four of the remaining "pike" had eaten hickory-shad (*Dorysoma cepedianum*), two had eaten catfish (Siluridæ) of which one was an Amiurus, two had eaten sheepshead (*Haploidonotus grunniens*), and one had taken a black bass and some sunfish (Centrarchidæ). The presence in the stomach of one of these fishes, of a catfish of medium size, with its poisonous pectoral and dorsal spines unbroken, was a striking illustration of the gastric energy of this species.

STIZOSTETHIUM VITREUM, Mitch. PIKE-PERCH. WALL-EYED PIKE. "Salmon."

This is far the finest of our river fishes—second to no fresh-water species except, possibly, some of the salmon family. It occurs in the great lakes, and throughout the State generally in the larger streams. It is a much larger fish than the preceding, not infrequently reaching a weight of twenty pounds. Certainly no fish of our waters is better deserving of attention than this. The only drawback to its increase is in its voracity; but, although it devours an immense number of other fishes, there is no evidence that it is wantonly destructive or that it eats more in proportion to its weight than the black bass.

Twelve of this species were examined, two of which were under three inches in length, and the others adult.

Food of the Young.

A specimen two inches long, taken in the Illinois R., at Pekin, June 2, 1880, had eaten only a minute fish. One, two and a half inches long, taken at the same place in June, 1878, had also eaten a small fish and a few Entomostraca (Cyprididæ and Daphniidæ). The appearance of these Entomostraca in the food of a fish of this size, makes it altogether probable that Stizostethium, like Perca, wholly depends on these minute Crustacea, when very young.

Food of the Adult.

The remaining specimens, taken from three localities, had eaten nothing but fishes, one-half of them only the hickory-shad or skip-jack (*Dorysoma cepedianum*). In one other specimen, this species was associated with a minnow (Cyprinidæ), and in still another with a small sunfish with three anal spines (Centrarchidæ). One of the remaining stomachs contained only an unrecognizable fish, and the other two contained Cyprinidæ, including the creek chub, *Semotilus corporalis.*

The two species of this genus agree so closely in food that they may well be discussed together. Apart from their exclusively piscivorous habit, the most interesting fact shown is the importance of the hickory-shad as food for this fish. We shall find accumulating evidence that this shad, utterly useless for human food, is, notwithstanding, one of the most valuable fishes in our streams. Nevertheless, not the slightest attention is paid to its preservation, much less to its encouragement. The fishermen commonly regard these fishes as a mere nuisance, and leave them to die on the bank by hundreds, rather than take the trouble to return them to the water. They are a very delicate species, and are easily killed by rough handling in the seine, but the majority of those captured might be saved with a little care.

The abundance of these fishes as compared with some other species in the river might seem to indicate that they

are common enough as it is. Few realize, however, the number of fishes needed to feed a pike-perch to maturity. Two or three items from my notes will furnish the basis for an intelligent estimate of this number.

From the stomach of a *Stizostethium canadense* caught in Peoria Lake October 27, 1878, I took ten well-preserved specimens of *Dorysoma*, each from three to four inches long; and from a *Stizostethium vitreum* I took seven of the same species, none under four inches in length. As the Dorysoma is a very thin, high fish, with a serrate belly, these were as large as a pike-perch can well swallow; and we may safely suppose that not less than five of this species would make a full meal for the pike-perch. The species is a very active hunter, and it is not at all probable that one can live and thrive on less than three such meals a week. The specimens above mentioned were taken in cold autumn weather, when most other fishes were eating but little; but, since fishes generally take relatively little food in winter, we will suppose that the pike-perch eats, during the year, on an average, at this rate per week for forty weeks, giving us a total *per annum* of six hundred Dorysomas destroyed by one pike-perch. We cannot reckon the average life of a Stizostethium at less than three years, and it is probably nearer five. The smallest estimate we can reasonably make as to the food of each pike-perch would therefore be somewhere between eighteen hundred and three thousand fishes like Dorysoma. A hundred pike-perch, such as should be taken each year along a few miles of a river like the Illinois, would therefore require one hundred and eighty thousand to three hundred thousand fishes for their food. Finally, when we take into account that a number of other species also prey upon Dorysoma, and that the whole number destroyed in all ways must not exceed the mere *surplus* reproduced—otherwise the species would be extinguished—we can form some approximate idea of the multitudes in which the food species must abound if we would support any great number of predaceous fishes. Dorysoma, being a mud-eater and a vegetarian, taking animal food only during the entomostracan

period, can probably be more readily maintained in large numbers in our muddy streams than any other fish.

It is evident that the increase of edible fishes without a corresponding supply of food will be largely time and labor thrown away. Probably if protected from wanton and ignorant destruction, the Dorysoma would abound sufficiently, as it is enormously prolific.

The following table is similar to that given for the preceding family. The mark † is used to indicate the occurrence of an element in too small an amount to figure in the ratios.

TABLE OF THE FOOD OF THE PERCIDÆ.

	PERCA.						STIZOSTETHIUM.
	One inch and under.	One to two inches.	Two to three inches.	Three to four inches.	River specimens.	Lake specimens.	
Number of specimens examined.....	2	9	4	4	18	12	26
I. FISHES..................	....	....	....	....	06	86	100
Undetermined..................	....	....	....	....	....	50	23
Acanthopteri..................	....	....	....	....	....	08	21
Undetermined..................	....	....	....	....	....	08	08
Pœcilichthys..................	....	....	....	....	06	....	....
Centrarchidæ..................	....	....	....	....	....	....	05
Undetermined..................	....	....	....	....	....	....	03
Micropterus..................	....	....	....	....	....	....	02
Haploidonotus..................	....	....	....	....	....	....	08
Dorysoma..................	....	....	....	....	....	....	41
Cyprinidæ..................	....	....	....	....	....	28	09
Undetermined..................	....	....	....	....	....	28	05
Semotilus..................	....	....	....	...	...	....	04
Siluridæ..................	....	....	....	....	....	....	08
Undetermined..................	....	....	....	....	....	....	04
Amiurus..................	....	....	....	....	....	....	04
II. MOLLUSCA..................	....	....	....	....	19	....	....
Physa heterostropha..................	....	....	....	†	05	....	....
Succinea..................	....	....	....	....	04	....	....
Valvata 3-carinata..................	....	....	....	....	01	....	....
Cyclas..................	....	....	....	....	05	....	....
Unio..................	....	....	....	....	04	....	....
III. INSECTA..................	....	34	100	45	24	....	....
Pupæ..................	....	....	....	....	†	....	....
1. *Diptera* (larvæ)..................	....	10	....	06	01	....	....
Undetermined..................	....	01	....	....	....	....	....
Chironomus..................	....	09	....	06	01	....	....
2. *Hemiptera*..................	....	23	12	04	....	....	....
Corixa..................	....	23	....	04	....	....	....
Undetermined..................	....	11	....	04	...	....	....
C. alternata..................	....	....	12	....	....	....	....
C. tumida..................	....	12	....	....	....	....	....
3. *Neuroptera* (larvæ)..................	....	01	88	35	23	....	....
Ephemeridæ..................	....	01	83	35	08	....	....
Undetermined..................	....	....	....	35	03	....	....
Palingenia..................	....	...	83	....	05	....	....
Agrionidæ..................	....	....	05	....	04	....	....
Libellulidæ..................	....	....	....	....	08	....	....
Phryganeidæ..................	....	....	....	....	03	....	....

TABLE OF THE FOOD OF PERCIDÆ—Continued.

	PERCA.						STIZOSTETHIUM.
	One inch and under.	One to two inches.	Two to three inches.	Three to four inches.	River specimens.	Lake specimens.	
Number of specimens examined.....	2	9	4	4	18	12	26
IV. CRUSTACEA............	....	66	....	55	48	14	†
1. *Decapoda*	....	....	....	....	10	14	....
Cambarus	....	....	....	....	04	14	....
Palæmonetes	....	....	....	....	06	....	....
2. *Amphipoda*	....	06	....	24	15	....	....
Undetermined	....	02	....	....	....	...	....
Allorchestes	....	04	....	24	15	....	....
3. *Isopoda*	....	....	....	01	23	....	....
Asellus	....	....	....	01	11	....	....
Mancasellus	....	....	....	....	12	....	....
4. *Entomostraca*	100	60	....	30	....	....	†
Cladocera	55	36	....	22	...	....	....
Daphniidæ	55	27	....	22	....	....	†
Undetermined	55	13	....	....	....	....	†
Simocephalus	....	†	....	....	....	....	....
Daphnia	....	12	....	22	....	....	....
Bosmina	....	02	....	....	....	....	....
Lynceidæ	....	09	....	....	....	....	....
Undetermined	....	07	....	....	....	...	....
Pleuroxus	....	†	....	....	....	....	....
Chydorus	†	02	....	....	....	....	....
Copepoda	45	24	....	....	....	....	....
Cyclops	45	24	....	....	....	....	....
Diaptomus	....	†	....	....	....	....	....
Ostracoda (Cypris)............	....	†	....	08	....	....	†
V. VEGETATION............	....	....	....	....	03	....	....

Family LABRACIDÆ. The Bass.

We have but two species of this family, the white bass and the brassy bass (*Roccus chrysops* and *Morone interrupta*). As far as their food is concerned, these are evidently equivalent species, agreeing closely in their general relations, and differing only in their distribution.

Roccus chrysops, Raf. White Bass.

This species is of medium abundance throughout the northern half of the State—most common in Lake Michigan. A curious fact of its distribution is its rarity in Fox River and the lakes connected with that stream. Indeed, during several days' active collecting in this region we did not see a single specimen, neither could we hear of the occurrence of the species in those waters, although we made careful inquiry for it among experienced fishermen.

My notes on its food relate only to eleven specimens, of which three, taken at South Chicago, in August, were young, but of unknown size. Two of these had eaten only Chironomus larvæ and the larvæ of a remarkable ephemerid? not yet determined, and the stomach of the third contained only a minute fish. The remaining eight individuals had depended chiefly on the larvæ of May-flies (sixty-nine per cent.). The other important articles of their food were twenty per cent. fishes (including one sunfish—Centrarchidæ) and eight per cent. isopod Crustacea (Asellus). Several attempts to secure food from Lake Michigan specimens were unsuccessful, as, being taken in pound-nets, their stomachs were always empty. Those studied were from various interior situations in the northern third of the State.

Morone interrupta, Gill. Striped Bass. Brassy Bass.

This fish replaces the preceding in the southern half of the State, the Illinois River forming a neutral zone between the respective territories of the two species.

The food of six specimens of this species was studied, all taken from the Illinois River from May to October.

Four of these were young. The smallest, one and a fourth inches long, taken at Peoria, in June, 1878, had eaten about equally of small *Dorysoma cepedianum* and Entomostraca—forty per cent. Leptodora and ten per cent. Cyclops. One, an inch and a half in length, taken at the same time and place, had eaten only Dorysoma, with a trace of Cyclops. The next, one and five-eighths inches in length, had eaten a small undetermined fish and

a few Daphnias. The fourth, one and seven-eighths inches long, caught at Peoria, in October, had eaten only larvæ and pupæ of Chironomus.

The two adult specimens were feeding chiefly upon the larvæ of Neuroptera—especially May-flies. An *Allorchestes dentata* and a few small grasshoppers also appeared in the food.

It will be seen that this species apparently agrees closely with the preceding in its food. The large amount of crustacean food in the smallest specimen shows that we should probably find still smaller Labracidæ depending upon these as strictly as the Percidæ.

Family CENTRARCHIDAE. The Sunfishes.

This interesting group, known, in some of its members, to every one who has ever seen a dozen fishes, is represented in Illinois by sixteen species, as the species of this family are now understood. The two black bass, included in this family for technical reasons, are, of course, the most important species. The rock bass, the croppie and the common sunfish (*Lepiopomus pallidus*), although not fishes of the first class, would be seriously missed if we were to lose them; and boyhood in the country would be quite another thing if it were not for the "pumpkinseed" in the mill-pond, whose barbaric splendor thrills the heart of the youthful fisherman as the more delicate beauties of the trout or salmon do those of tougher fibre.

I have studied the food of thirteen species of this group, as indicated by two hundred and thirty-seven specimens, well distributed in time and area.

Decided differences in food made out in the various genera, have been found to coincide with differences in a few structures about the mouth in such a way that one may predict, from an examination of these structures, what the leading peculiarities of the average food of any genus will be.

MICROPTERUS PALLIDUS, Raf. LARGE-MOUTHED BLACK BASS.

This famous species is too well known to require extended comment. The ordinary fishermen rarely distin-

guish it from the following; and, indeed, sportsmen do not always recognize the difference.

I have examined the food of thirty-one specimens of this species, fourteen of which were adults, and the remainder young, of different ages.

Food of the Young.

The first group, consisting of five specimens under one inch in length (ranging from $\frac{5}{8}$ to $\frac{3}{4}$ in.), represents three localities—Crystal Lake, in McHenry county, the Illinois River at Pekin, Tazewell county, and the same stream at Starved Rock, in LaSalle county. They were taken in June, July and August of three different years. It is evident, therefore, that the common features of their food cannot well be attributed to any other than their similar size.

The entire food of these fishes consisted of small Crustacea—all Entomostraca except seven per cent., eaten by a single fish, which consisted of the very young of some undetermined amphipod—probably Allorchestes. Eighty-seven per cent. of the food was Cladocera, principally *Bosmina longirostris,* Müll. *Simocephalus americanus,* Birge, was also an important element; and traces appear of Chydorus, Pleuroxus and *Eurycercus lamellatus.* About six per cent. of Cyclops had been eaten.

In the food of the next group—six specimens, from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long—minute fishes and insects appear. The fishes (twenty-nine per cent.) were not large enough to determine. The insects (forty-six per cent.) were mostly young water-bugs (Corixa), the principal part of which were about half grown. The adults were all *Corixa tumida,* Uhl. The Entomostraca drop to twenty-five per cent., about equally Cladocera and Cyclops. Among the former were many specimens of *Simocephalus americanus,* and a few of the rare and curious Leptodora mentioned in a previous paper.* The specimen in which this was found was taken at Peoria, in June, 1878. All of this group were taken from the Illinois River, but at different places and dates. Some, taken at the same place and

* See Bull. No. 2, Ill. State Lab. Nat. Hist., p. 88.

time as others of the preceding group, differed from them in the smaller number of Entomostraca eaten, and the larger number of insects—differences evidently only to be explained as due to the different sizes of the fishes.

The next two specimens, between two and three inches long, had eaten only insects, chiefly *Corixa tumida.*

Four specimens, ranging from three to three and a half inches in length, all taken from a lake in the Illinois River bottom, in October, 1879, had eaten nothing but insects—almost wholly Corixas and the larvæ of May-flies (Ephemeridæ). The Corixas were *C. alternata*, Say, and *C. tumida,* Uhl.

Food of the Adult.

Turning to the food of the fourteen adults, we note the total disappearance of Entomostraca, the merely accidental occurence of insects, the appearance of crawfishes (*Cambarus immunis*), which amount to seven per cent. of the whole food, and the great predominance of fishes (eighty-six per cent.). These were of sufficient variety to show that no group is safe from the appetite of the bass unless it be the gar.

Perch, minnows, catfish and hickory-shad were recognizable. The last were much the most abundant, occurring in eight of the specimens, and constituting fifty-eight per cent. of the food of the whole number. They ranged from three to six in each stomach, and were from three to four inches long. It should be noted, however, that these were all eaten by fishes taken at the same place and time. A large mouse was found in the stomach of one bass from the Illinois River.

We may generalize these data by saying that this black bass lives, at first, wholly on Entomostraca; that it commences to take the smallest aquatic insects when about an inch in length, and that minute fishes appear in its diet almost as early. From this forward, the Entomostraca diminish in importance, and the insects and fishes become larger and more abundant in the food. The adults eat voraciously of a great variety of fishes—especially the hickory-shad (Dorysoma)—and feed upon crawfishes also to some extent.

MICROPTERUS SALMOIDES, Lac. SMALL-MOUTHED BLACK BASS.

This species, called also tiger bass, river bass, etc., is the black bass *par excellence.* It ranges usually in deeper and clearer water than the preceding; but both are often taken together.

I have made full notes of the food of twenty-seven specimens—three adult and the others young. I had none of this species under an inch in length; but, judging from the general resemblance of the food of this and the preceding bass at later ages, I do not doubt that this will also be found to feed at first on Entomostraca, although insect food is possibly more important to it from the beginning.

Seven individuals, from one to two inches in length, were all taken in July from rocky ripples in the Fox River, at Dayton, Ill., a few miles above the mouth of the stream. These had eaten only five per cent. of Entomostraca—the whole remainder of the food consisting of insects, of which *Corixa tumida,* young and adult, and larvæ of May-flies and darning-needles (Agrionidæ) were the most important kinds. Four per cent. of the larvæ of Chironomus are worthy of notice. The scarcity of Entomostraca in the food of fishes as small as these is probably due to the situation in which these specimens occurred, as few Entomostraca are to be found in swift water. The same fact will account for the presence of Chironomus larvæ—found abundantly under stones in rapid streams.

The next ten specimens, between two and three inches long, were taken in July, partly at the same place as the preceding, and partly from the Illinois River, a few miles below the mouth of the Fox. These differed from the smaller specimens chiefly in the appearance of fishes in the food (five per cent.) and in the absence of Neuroptera. Probably the last of these differences, at least, was accidental. A few larvæ of aquatic Coleoptera (Hydrophilidæ and Dytiscidæ) were noticed. Corixas, including *C. tumida,* Uhl, and *C. signata,* Fieb.,* amounted to eighty-two per cent. of the food.

In those ranging from three to four inches in length (seven individuals), the fishes eaten rise to fourteen per

* Determined by Mr. Uhler.

cent., but the insects drop away to seven per cent., and the Crustacea rise to seventy-nine. Here, however, difference of locality interferes to prevent any satisfactory comparison with other ages—as these specimens were all taken in August, from Calumet River, at South Chicago. This slow stream, clogged with Algæ and a great variety of other aquatic plants in midsummer, also swarms with Crustacea—especially the little *Allorchestes dentata.* This species made sixty-three per cent. of the food of these specimens; and an undetermined species of Asellus, fourteen per cent. A few *Gammarus fasciatus* were also found. The insects were Corixa and larvæ of Agrionidæ.

It will be seen that, excepting the gradual increase of the number of fishes eaten, these data show no especial difference in the young of different ages. Smaller specimens and a larger number from a greater variety of situations, would be necessary to exhibit this difference.

The food of the young as a whole, apparently, does not differ essentially from that of the large-mouthed species, except in the probably greater importance of the insect element—especially Corixas, which in these twenty-four specimens amounted to fifty per cent. of the food—and the inferior importance of fishes.

This peculiarity is expressed in a slightly different manner in the food of the adult. The three specimens examined had eaten only fishes (*Noturus flavus* and *Percina caprodes*) and crawfishes (*Cambarus propinquus*)—thirty-eight per cent. of the former and sixty-two per cent. of the latter.

This is the first of several instances in which the ratio of fishes in the food of allied species and genera was found to correspond to the size of the mouth, being largest in those with the largest oral opening.*

*The frequency with which these two species of black bass are confounded makes it desirable that a single reliable character should be selected by which they can be invariably distinguished, whatever the age of the specimen. This character is afforded by the size of the scales, the small-mouthed species having the smaller scales. In this species there are eleven longitudinal rows of scales between the dorsal fin and the row of perforated scales running along the middle of the side called the lateral line. In the large-mouthed species, there are never more than nine such rows. The young are easily distinguished by the longitudinal black stripe along the side of the large-mouthed bass, which is wanting in the young of the other species.

TABLE OF THE FOOD OF MICROPTERUS.

	M. PALLIDUS.					M. SALMOIDES.			
	Under one inch.	One inch to two.	Two to three inches.	Three to four inches.	Adults.	One inch to two.	Two to three inches.	Three to four inches.	Adults.
Number of specimens......	5	6	2	4	14	7	10	7	3
I. FISHES	....	29	....	....	86	....	05	14	38
Acanthopteri..............	....	....	....	....	15	....	....	....	....
Percina	....	....	....	....	....	....	....	....	13
Perca.................	....	....	....	....	08	....	....	....	....
Dorysoma	....	....	....	....	58	....	....	....	....
Cyprinidæ................	....	....	....	....	06	....	05	....	....
Campostoma	....	....	....	....	06	....	....	....	....
Siluridæ................	....	....	....	....	07	....	....	....	....
Noturus flavus	....	....	....	....	....	....	....	....	25
II. INSECTS.........	....	46	100	100	†	95	89	07	....
Undetermined larvæ	....	....	50	....	....	....	....	....	....
1. *Diptera* (larvæ)..........	....	02	....	....	....	04	05	....	....
Culicidæ...............	....	....	....	....	....	....	01	....	....
Chironomus	....	02	....	....	....	04	....	....	....
Muscidæ.	...	....	....	....	....	....	04	....	....
2. *Coleoptera* (larvæ).......	....	....	....	....	....	....	02	....	....
Dytiscidæ.............	....	....	....	....	....	....	02	....	....
Hydrophilidæ	....	....	....	....	....	....	†	....	....
3. *Hemiptera*...............	....	44	50	57	†	51	82	03	....
Terrestrial............	....	....	....	†	....	....	....	....	....
Zaitha...............	....	....	....	....	†	....	....	....	....
Corixa	....	42	50	57	....	51	82	03	....
Notonecta	....	02	....	....	....	....	....	....	....
4. *Neuroptera* (larvæ)......	....	....	....	43	†	39	†	04	....
Ephemeridæ	....	....	....	43	....	28	†	....	....
Agrionidæ	....	....	....	....	†	11	....	04	....
III. CRUSTACEA.....	100	25	....	†	07	05	04	79	62
1. *Decapoda*	....	....	....	....	07	....	....	....	62
Cambarus,.............	....	....	....	....	07	....	....	....	62
2. *Amphipoda*	07	....	....	....	....	....	....	65	....
Gammarus.............	....	....	....	....	....	....	....	02	....
Allorchestes	....	....	....	....	....	....	....	63	....
3. *Isopoda* (Asellus).........	....	....	....	....	....	...	....	14	....
4. *Entomostraca*	93	25	....	....	....	05	....	....	....
Cladocera..............	87	14	....	†	....	05	04	....	....
Daphniidæ	26	12	....	†	....	05	04	....	....
Simocephalus......	18	06	....	....	....	....	....	....	....
Bosmina..........	60	....	....	....	....	...	....	....	....
Leptodora	....	02	....	....	....	....	....	....	....
Copepoda (Cyclops)....	06	11	....	....	....	†	†	....	....
IV. VEGETATION ...	....	....	....	....	....	....	02	....	....
Endogenous	....	....	....	....	....	....	02	....	....
Algæ.....................	....	....	....	....	†	....	†	....	....
MISCELLANEOUS.....	....	....	....	....	07	....	....	....	....

Amblopltes rupestris, Raf. Rock Bass.

This favorite and widely distributed species does not differ from the other fishes mentioned in respect to the food of the young. The smallest specimen examined, five-eighths of an inch long, contained only a few Cladocera (Pleuroxus). Another, three-fourths of an inch long, had eaten Daphnids (seventy-five per cent.), Cyclops (ten per cent.), and larvæ of Chironomus. A third, seven-eighths of an inch long, contained only minute fragments of a few larvæ of Neuroptera. These specimens were all taken from Fox River in July, 1879. The remaining young of the year were living chiefly on Corixa (eighty-three per cent.), as were also the young of the year preceding (ninety per cent.), so far as could be judged from the food of two specimens, from three to four inches in length. Some land insects, ephemerids, water-beetles, and a few Allorchestes were also found in the food.

Four adult specimens, taken at Ottawa on the 8th of July, had eaten some minute fishes (fifteen per cent.), a few water-beetles, including *Tropisternus limbatus*, over forty per cent. of Neuroptera larvæ, and about thirty per cent. of small crawfishes. The Neuroptera included Baëtis and other ephemerids (twenty per cent.), Agrionidæ and large Libellulidæ, and fifteen per cent. of case-flies (Phryganeidæ). Pond-weed (Potamogeton) found in two stomachs, had probably been taken accidentally.

Chænobryttus gulosus, C. & V. Wide-mouthed Sunfish.

This fine species is among the commonest of the family in the lakes and ponds of southern Illinois, where it is commonly known as the "goggle-eye."

The northern limit of its range, so far as known, is the Illinois River valley. In number and habitat it replaces in the south the *Eupomotis aureus* of the north; but this equivalence is only apparent as the two species differ widely in food. From its size and abundance, it is no insignificant food resource.

Food of the Young.

My smallest specimens were from lakes in the Mississip-

pi bottom, near Bird's Point, Missouri. Two of these, one inch long and under, taken in September 1879, had eaten only *Bosmina longirostris* and Cyclops. Insect food first appears in specimens one and one-half inches long. Eight specimens, between one and three inches long, six of which were taken from a lake in the Illinois bottoms, near Pekin, in October, 1879, and two from a lake in Kentucky, near Cairo, Illinois, had eaten about forty per cent. Entomostraca, thirty per cent. Neuroptera larvæ, and thirty per cent. Corixas and Diptera larvæ. *Daphnia pulex, Simocephalus americanus, Bosmina longirostis,* Chydorus, Pleuroxus and Cyclops, were among the Entomostraca. *Corixa alternata* was found among the Hemiptera. Most of the Diptera (i. e., fifteen per cent.) were larval Chironomus.

Food of the Adult.

Six adults from rivers, streams and lakes in central and southern Illinois, show the usual change in food, carried farther than in the preceding species. Entomostraca disappear—except a few Chydorus in a single specimen—and fishes become the principal reliance, amounting to forty-seven per cent. of the food. Corixas, larvæ of *Palingenia bilineata,* and some terrestrial Coleoptera—*Anomala binotata*—which made half the food of one specimen, are the remaining items.

The especially piscivorous habit of this species is probably related to the size of its mouth, which is much the largest among the sunfishes proper. A similar relation has already been noticed between the two black bass.

TABLE OF FOOD OF AMBLOPLITES AND CHÆNOBRYTTUS.

	AMBLOPLITES.				CHÆNOBRYTTUS.			
	Under one inch.	One inch to two.	Three to four inches.	Adults.	One inch and under.	One inch to two.	Two to three inches.	Adults.
Number of specimens examined	3	3	2	4	2	4	4	6
I. FISHES	....	....	....	15	....	....	....	47
II. INSECTS	39	99	97	52	....	57	64	53
Undetermined larvæ	....	16	....	01	....	....	....	....
Caterpillars	....	17	....	....	....	....	....	....
1. *Diptera* (larvæ)	05	03	....	06	....	32	04	....
Chironomus	05	03	....	....	....	26	04	....
2. *Coleoptera*	....	....	02	03	....	....	....	10
Terrestrial	....	....	01	....	....	....	....	10
Aquatic	....	....	01	03	....	....	....	....
Dytiscidæ	....	....	01	01	....	....	....	....
Hydrophilidæ	....	....	....	02	....	....	....	....
3. *Hemiptera*	....	63	95	....	....	....	20	18
Corixa	....	63	90	....	....	....	20	18
Hygrotrechus (young)	....	....	05	....	....	....	....	....
4. *Neuroptera* (larvæ)	34	....	....	42	....	25	40	25
Ephemeridæ	....	....	....	21	....	03	12	25
Palingenia	....	....	....	....	....	....	....	25
Baetis	....	....	....	01	....	....	....	....
Agrionidæ	....	....	....	01	....	10	28	....
Libellulidæ	....	....	....	05	....	....	....	....
Phryganeidæ	....	....	....	15	....	....	....	....
III. ARACHNIDA (Hydrachna)	....	....	....	†	....	....	....	....
IV. CRUSTACEA	61	....	03	31	100	43	34	†
Decapoda (Cambarus)	....	....	....	31	....	....	....	....
Amphipoda	....	....	03	....	....	....	....	....
Entomostraca	61	01	....	....	100	43	34	†
Cladocera	58	....	....	....	70	24	34	†
Daphnia	....	....	....	....	....	....	21	....
Bosmina	....	....	....	....	70	....	....	....
Pleuroxus	33	....	....	....	....	†	....	....
Chydorus	....	....	....	....	....	....	†	†
Copepoda	03	01	....	....	30	19	....	....
V. VEGETATION	....	....	....	02	....	....	02	....
Potamogeton	....	....	....	02	....	....	....	....
Algæ	....	....	....	....	....	....	02	....

APOMOTIS CYANELLUS, Raf. BLUE-SPOTTED SUNFISH.

This species, distributed throughout the State, is especially abundant in central Illinois, where it is the common fish of the ponds and smaller streams—"the sun-

fish'' of the country schoolboy and the picnic party. It is the constant companion of the ''bull-head'' (Amiurus) and ''shiner'' (Notemigonus) in the small stagnant ponds of the prairie regions, and of the ''chub minnow'' (Semotilus) in muddy creeks. It was found abundant with Centrarchus, Aphredoderus and *Amiurus catus*, in the rapidly drying mud-holes,* only a few feet across, left by the retreating overflow of the Mississippi bottoms, in Union county.

Food of the Young.

The smallest of nineteen specimens studied, was one inch in length—taken in July, in a prairie pond near Normal. Ninety-five per cent. of its food was Cyclops and three per cent. Daphnids. The trifling remainder consisted of a Corixa just hatched, and a Chironomus larvæ.

Nine specimens, ranging from one to two and a fourth inches in length, vary so little in food that it is not worth while to treat them separately. These were taken from various ponds, streams and lakes in central Illinois. Their food was distributed quite generally through the various orders of insects and crustaceans accessible to them, showing the indifferent appetite of this fish and the general effectiveness of its collecting apparatus.

Larvæ of Chironomus, Dytiscidæ, Staphylinidæ, Corixas, Ephemerid larvæ, Decapoda, Isopoda, Cladocera, Cyprids and Copepoda were all found in considerable quantities in the food of these specimens. As usual, the most important insects were Corixas and May-flies—sixteen per cent. of the former and twenty-nine per cent. of the latter. About eight per cent. of the food was Cladocera (Daphnia, Simocephalus, Pleuroxus, Chydorus).

Food of the Adult.

The eight adults, from northern and southern Illinois, differed from the young in the disappearance of En-

*All the specimens taken from these holes, so muddy that the water was almost opaque, were of a peculiarly bleached appearance—many of them almost colorless—a fact of interest relative to the laws of coloration among fishes.

tomostraca from the food, the larger size of the insects taken, and the appearance of fishes and crawfishes.

Among the insects were a large Hydrophilus unknown to me, but nearly as large as *H. triangularis,* the larva of *Corydalus cornutus,* of Libellula and of some Ephemerid. The fishes composed about thirty-six per cent. of the food. The only recognizable specimens were a small Cyprinoid and a young buffalo-fish (*Ichthyobus bubalus*). Crawfishes and the river shrimp (Palæmonetes) had been eaten by two of the specimens.

LEPIOPOMUS PALLIDUS, Mit. COMMON SUNFISH.

This abundant, hardy and voracious species, is found throughout the State, and may be regarded as the typical sunfish. It is most plentiful in the larger rivers in central Illinois, being replaced in ponds by *Apomotis cyanellus.*

Consistently with its wide range and varied habitat, it is a general feeder for a sunfish—peculiar only in the fact of its strictly non-predaceous character. Of forty-five specimens examined, only one had eaten a fish, and that one only a single small darter.

Undifferentiated Centrarchidae.—I introduce here the food of six specimens of this family which were too small for determination. They were too deep for Micropterus, and as they had but three anal spines, could not have been Ambloplites or Pomoxys. They were probably *Lepiopomus pallidus.* All were taken from the Illinois River —a part of them near La Salle, in July, 1879—the others from Peoria, in June, 1878.

The smallest (seven-sixteenths of an inch long) had eaten only Daphniidæ. The next in size (one-half inch) contained Cyclops (ninety-eight per cent.) and Chydorus. Nearly the whole of the food of the remaining four was Daphniidæ (ninety-four per cent.), including *Daphnia pulex.*

Food of the Young.

My smallest specimens, five in number, ranging from three-fourths of an inch to one inch, were taken in Au-

gust, September and October, at Pekin, Peoria, and Mackinaw Creek, Woodford county. Neither locality nor date seems to have made any marked difference in their food, the principal elements of which were Entomostraca and Chironomus larvæ—fifty-seven per cent. and thirty-seven per cent. respectively.

A few water-spiders (Hydrachnidæ) and undetermined Amphipoda were the other items. The Entomostraca were all Cyclops (twenty per cent.) and Cladocera (*Simocephalus vetulus* and *americanus, Bosmina longirostris* and *Pleuroxus dentatus*).

Nine specimens, between two and three inches long, were caught at the same times and places as the preceding, except that one specimen from Mackinaw Creek was taken in June, and one taken in September was from Clear Lake, Kentucky. The greater size of these specimens was indicated by the appearance of a few Neuroptera larvæ in the food—eight per cent. In other essential respects, the food was like that of the foregoing group. One specimen had eaten largely of water-mites and another of Cyprids (fifty per cent.), and these elements have therefore greater prominence in the averages. Chironomus larvæ and Entomostraca now sum up eighty-one per cent.

In the third group of the young, consisting of seven fishes, between two and three inches long, the Chironomus larvæ remain about as before (thirty per cent.), Corixas appear (twenty-five per cent.) and Neuroptera larvæ rise to fourteen per cent. Entomostraca now fall away to a trifle, and larger percentages of Amphipoda appear. Single fishes had eaten the larvæ of a Gyrinid beetle, portions of the Polyzoan *Pectinatella magnifica,** Leidy, and an earthworm—the latter probably nibbled from some fisherman's hook.

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* This animal forms the large, translucent masses found in midsummer in the slow water along the margins of the Illinois River and elsewhere throughout the state, usually collected about a stick or a stem of a water-weed. They vary from the size of a walnut to that of half a bushel. The fragments were easily recognized by the peculiar form and armature of the winter eggs (statoblasts), which are discoidal and bordered with a row of slender double hooks, shaped something like an anchor.

These specimens were all from the Illinois River, in June, July, October and November.

Food of the Adult.

The twenty-four adults examined were from various parts of the State north of the center; and, as the food has been found to differ so widely according to the local situation, I have treated them in three groups—the first including those taken in the clear, inland, northern lakes; the second those from Calumet River, at South Chicago, and the shallow, muddy lakes of that vicinity, and the third those from the Illinois River from Ottawa to Peoria.

The specimens from the northern lakes were taken in May and June. Sixty-two per cent. of the food consisted of Neuroptera—eight per cent. being a black caddis-fly (*Sialis infumata*) and the remainder the larvæ of large dragon-flies (Libellulidæ), Agrions (eleven per cent.) and Baëtis (two per cent.). *Allorchestes dentata* was the next most important element (twenty-seven per cent.). A number of terrestrial insects besides Sialis appeared in the food. These included a Harpalid beetle, an *Aphodius fimetarius,* and some grasshoppers (Tettigidæ, etc.).

The second group of four, from Calumet River, and from Lake George, Indiana, was peculiar in the number of tetradecapod Crustacea and case-worms taken, and especially in the amount of vegetation eaten.

The Crustacea were Allorchestes (thirty-two per cent.) and Asellus (twenty per cent.). The vegetation was present in such quantities as to make it evident that it had been taken as food. It amounted to about a fourth of the contents of these stomachs. The stomach of one fish was packed with a piece of the stem of a plant (apparently a Scirpus) a third of an inch in diameter and six inches long. Three others contained smaller amounts of confervoid Algæ.

The fifteen specimens remaining were taken from the Illinois in May, July, August, October and November. Their food was especially noticeable for the presence of

mollusks (sixteen per cent.), for the number and variety of land insects (fifteen per cent.), and for the large amount of vegetation it contained (thirty-one per cent.). A single small fish—the only one taken by these forty-five specimens—was also noticed.

The mollusks included Planorbis, Physa, Amnicola and Vivipara. Among the insects were ants, caterpillars, flies, *Anisodactylus discoideus* and other Harpalids, *Aphodius inquinatus,* wire-worms, minute curculios, *Cryptocephalus* 4-*maculatus, Diabrotica* 12-*guttata,* Colorado potato beetles, flea-beetles, plant-bugs (Pentatomidæ), crickets (Nemobius), locusts, katydids (*Phaneroptera curvicauda*), grasshoppers and case-flies.

The vegetable food, as far as determined, consisted of Ceratophyllum, *Nais flexilis* and confervoid Algæ. Fragments of Polyzoa were noticed. *Coptotomus interrogatus,* Gyrinid larvæ,* *Tropisternus limbatus* and other Hydrophilidæ, larval and adult, a large Nepa, larvæ of *Palingenia bilineata* and other May-flies, of Agrions and dragon-flies were among the aquatic insects taken.

The Crustacea were limited to small crawfishes (two per cent.), a trace of Allorchestes, and a few Aselli (four per cent.).

On comparing specimens from northern Illinois with those taken from the Illinois River in the same month, I find that there are no common seasonal food characters, and that the differences of food are therefore due to difference of locality and not to difference of time represented by the groups. Concerning the entire number of adults, we can therefore say that their food ranges through the whole list of the smaller mollusks, terrestrial and aquatic insects, and smaller crustaceans (above Entomostraca) accessible in their localities, and that they feed largely on aquatic vegetation. A striking negative feature is the almost total absence of fishes in the food—a fact which corresponds with the relatively small size of the mouth.

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* Several of these little-known larvæ were found in the stomachs of this species,—some of them in suitable condition for description.

TABLE OF FOOD OF APOMOTIS AND LEPIOPOMUS.

	Apomotis.			Lepiopomus.						
	One inch long.	One to four inches.	Adults.	One inch and under.	One inch to two.	Two to three inches.	Northern lakes.	Calumet river and lakes.	Illinois river.	Total adults.
Number of specimens..	1	10	8	5	9	7	5	4	15	24
I. FISHES...........	....	....	36	....	....	....	....	....	10	01
Undetermined.........	....	....	10	....	....	....	....	....	....	....
Etheostomatidæ.......	....	....	....	....	....	....	....	....	01	....
Cyprinidæ	....	....	13	....	....	....	....	....	....	....
Ichthyobus............	....	....	13	....	....	....	....	....	....	....
II. MOLLUSKS.......	....	....	....	....	....	....	....	....	16	10
1. *Gasteropoda*........	....	....	....	....	....	....	....	....	16	10
Undetermined........	....	....	....	....	....	....	....	....	04	....
Planorbis	....	....	....	....	....	....	....	....	†	....
Physa...............	....	....	....	....	....	....	....	....	05	....
Vivipara...........	....	....	....	....	....	....	....	†	07	....
Amnicola	....	....	....	....	....	....	....	....	†	†
2. *Acephala*...........	....	....	....	....	....	....	....	....	†	....
III. INSECTA........	02	79	42	37	34	72	70	23	43	45
Undetermined.........	....	12	01	....	....	02	....	....	....	....
Terrestrial	....	07	....	....	....	....	05	01	15	12
Aquatic...............	02	60	41	37	34	70	65	22	28	33
1. *Diptera* (Chironomus)	01	09	....	37	26	30	....	†	01	01
2. *Coleoptera*..........	....	02	05	....	....	01	01	01	09	06
Undetermined.......	....	....	....	....	....	....	....	†	04	....
Dytiscidæ...........	....	02	....	....	....	....	....	....	02	....
Undetermined.....	....	02	....	....	....	....	....	....	....	....
Larvæ	....	....	....	....	....	....	....	....	01	....
Coptotomus	....	....	....	....	....	....	....	....	01	....
Gyrinidæ (larvæ)......	....	....	....	....	....	01	....	01	01	....
Hydrophilidæ	....	....	....	....	....	....	01	....	02	....
Undetermined.......	....	....	05	....	....	....	....	....	01	....
Tropisternus	....	....	....	....	....	....	....	....	01	....
3. *Hemiptera*..........	01	16	03	†	....	25	02	01	04	02
Undetermined.......	....	....	....	†	....	....	....	....	....	....
Corixa	01	16	03	....	....	25	01	....	04	....
Nepa	....	....	....	....	....	....	01	....	....	....
Ranatra.............	....	....	....	....	....	....	....	01	....	....
4. *Neuroptera*.........	....	33	33	....	08	14	62	20	14	24
Larvæ (undetermined)..	....	....	....	....	01	....	....	....	....	....
Ephemeridæ (larvæ)....	....	29	27	....	07	....	02	....	05	03
Baetis...............	....	....	....	....	....	....	02	....	....	....
Palingenia	....	....	01	....	....	....	....	....	04	02
Agrionidæ (larvæ).....	....	....	06	....	....	14	11	....	†	10
Libellulidæ (larvæ)....	....	04	02	....	....	....	41	....	02	02

TABLE OF FOOD OF APOMOTIS AND LEPIOPOMUS—Continued.

	Apomotis.			Lepiopomus.						
	One inch long.	One to four inches.	Adults.	One inch and under.	One inch to two.	Two to three inches.	Northern lakes.	Calumet river and lakes.	Illinois river.	Total adults.
Number of specimens..	1	10	8	5	9	7	5	4	15	24
Sialidæ	....	....	04	....	....	....	08	....	07	06
Sialis	....	....	....	....	....	....	08	....	07	06
Corydalus (larvæ)	....	....	04	....	....	....	....	....	....	....
Phryganeidæ	....	....	....	....	....	....	....	20	....	03
IV. ARACHNIDA	....	....	....	04	11	01	01	....	....	....
Spiders	....	....	....	....	....	....	01	†	....	....
Hydrachnidæ	....	....	....	04	11	01	....	....	†	....
V. CRUSTACEA	98	21	20	59	55	06	27	52	06	18
Decapoda	....	01	20	....	....	....	....	....	02	01
Undetermined	....	01	....	....	....	....	....	....	....	....
Cambarus	....	....	08	....	....	....	....	....	02	....
Palæmonetes	....	....	12	....	....	....	....	....	....	....
Amphipoda	....	....	....	02	....	05	27	32	....	11
Undetermined	....	....	....	02	....	....	....	....	....	....
Allorchestes	....	....	....	....	....	05	27	32	†	....
Isopoda (Asellus)	....	04	....	....	....	....	....	20	04	06
Entomostraca	98	16	....	57	55	01	....	†	....	....
Cladocera	....	08	....	37	14	....	....	†	....	....
Daphniidæ	03	07	....	33	12	....	....	....	....	....
Lynceidæ	....	01	....	04	02	01	....	†	....	....
Ostracoda	....	03	....	....	06	....	....	†	†	....
Copepoda	95	05	....	20	35	†	....	....	....	....
VI. VERMES	....	....	....	....	....	20	....	....	03	02
Undetermined	....	....	....	....	....	†	....	....	....	....
Polyzoa	....	....	....	....	....	11	....	....	03	02
Lumbricus	....	....	....	....	....	09	....	....	....	....
VII. VEGETATION	....	....	02	....	....	01	02	25	31	24
Phænogamous	....	....	02	....	....	01	02	21	19	16
Algæ	....	....	....	....	....	....	....	04	12	08

XENOTIS MEGALOTIS, Raf. LONG-EARED SUNFISH.

This little species is not at all common in the State, but has been taken by us from the middle course of Fox R., from tributaries of the Illinois R., and from ponds in Union county and southern Illinois.

Unfortunately, the three specimens examined had not lately taken food, and only a very imperfect notion of their usual aliment can be given. Corixa, Ephemerid

larvæ, Chironomus larvæ, the tube of a case-worm, a few fish-scales and an indeterminable aquatic beetle were the only objects found.

XENOTIS PELTASTES, Cope.*

This beautiful little fish, hitherto taken in this State only in very small number from Fox R., was found quite abundant in the "slip" at South Chicago, in June, 1880. The three opened had eaten more larvæ of Chironomus than anything else (sixty per cent.). Next came sixteen per cent. of mollusks, then Allorchestes and Asellus, Corixa, Gyrinid larvæ and a few terrestrial larvæ (Chrysomelidæ). The large percentage of Chironomus was probably owing to the situation—a foul and muddy little bay, serving as a harbor for fishing boats.

EUPOMOTIS AUREUS, Wahl. PUMPKIN-SEED. BREAM.

This species swarms in the lakes and ponds of northeastern Illinois, but is much less abundant in the Illinois R., and in the southern part of the State is almost unknown. The cause of this limitation of its range is apparently climatic, as there is certainly nothing in its food, nor, apparently, in any of its habits, to exclude it from our southern waters. Indeed, I do not see that its place is taken by any other fish to the southward. No other, unless *Eupomotis pallidus,* resembles it in food, and this is too infrequent to replace it. My knowledge of its food is based upon the study of twenty-five specimens ranging from one and one-half inches upward, taken from the Illinois, Fox and Calumet rivers, and from Long, Crystal and Nipisink lakes and Lake George, in central and northern Illinois and Indiana. The months of May, June, July, August and October are represented by these specimens.

Food of the Young.

The nine smaller specimens, from one and one-half to two inches long, show at once two prominent peculiarities of the food. The larvæ of Chironomus compose fifty-one

* It is considered doubtful, by Dr. Jordan, if this species and the preceding are distinct.

per cent. of the food, and Entomostraca of the order Ostracoda (Cyprids), twenty-six. As both these are found most abundantly in muddy bottoms, it is evident that the fish is, at least at first, a bottom feeder. Traces of mollusks appear thus early, as well as a few Ephemerid larvæ (five per cent.). The remainder of the food was insects' eggs and Daphnids—chiefly *Simocephalus americanus*—(twelve per cent.). Chydorus was found in five specimens, but in too small quantity to figure in the averages.

Five specimens were studied between two and three inches long. In these the same food characters continue, modified somewhat by the introduction of larger objects. The Chironomus larvæ stand at forty-four per cent., and the Cyprids at eighteen per cent. Fourteen per cent. of Allorchestes and eleven per cent. of Neuroptera larvæ are the only important elements remaining. Two per cent. of young Unios were noticed. Nearly half of the food of two larger specimens, between two and three inches long, consisted of mollusks—chiefly Physa. A few Chironomi and about equal quantities of Ephemerid larvæ and Allorchestes were all the remaining food. Entomostraca therefore disappear at this point.

Food of the Adult.

Forty-six per cent. of the food of the nine adults consisted of Mollusca, including Planorbis, Amnicola and *Valvata tricarinata,* and six per cent. of undetermined bivalves.

The insect food was twenty per cent. of the whole. Crustacea twenty-two per cent., and vegetation twelve per cent. Half of the last was Chara, and the remainder chiefly Myriophyllum and Algæ. The Crustacea were all Allorchestes and Asellus. The insects included a trace of Chironomus larvæ and a few water-beetles (Hydrophilidæ), and the usual Neuroptera larvæ, among which caseflies of the genus Leptocerus were noticed.

Not a trace of fishes was found in the stomachs of these specimens; and this fact, together with the large percentage of molluscan food, constituted the leading alimentary peculiarities of the species.

The first of these is doubtless related to the small mouth —the second to the stout, blunt pharyngeal teeth—a character used in defining the genus. In all the preceding species the pharyngeals are set with more slender, pointed teeth.

EUPOMOTIS PALLIDUS, Ag. PALE SUNFISH.

Having but few specimens of this rather uncommon species, I have examined the food of but one—enough to indicate that it probably agrees closely with the preceding species.

This fish, taken in Clear Lake, Ky., had eaten largely of small Mollusca—young Unionidæ, Planorbis, Amnicola, etc. These amounted to seventy-five per cent. of the food. The remaining elements were Chironomus larvæ, several small water-beetles, (*Hydroporus hybridus, Cnemidotus* 12-*punctatus,* and *Haliplus,* sp.), an unknown aquatic pupa and a little pond-weed.

CENTRARCHUS IRIDEUS, Lac.

This little species is found in considerable numbers in ponds and streams in the southern hill-country of Illinois. My specimens, all taken in July, are from ponds and streams in the Mississippi bottoms in Union and Jackson counties, and from Cache R. and its tributaries in Johnson county.

Five of the young, from three-fourths of an inch to an inch in length, had eaten seventy-one per cent. of Entomostraca and twenty-one per cent. of larvæ of Chironomus, and, for the rest, about equal quantities of Ephemerid larvæ and young Allorchestes, with a trace of water mites (Hydrachnidæ).

Thirty-eight per cent. of the food was Cyclops; Cyprids amounted to twenty-one per cent.; and twelve per cent. of Simocephalus completed the ratio of Entomostraca. The smallest specimen, three-fourths of an inch long, had eaten sixty per cent. Simocephalus and forty per cent. Cyclops.

About a fifth of the food of one specimen, an inch and an eighth in length, consisted of minute young Corixas, the remainder being about equally Cyclops and Cyprids.

TABLE OF FOOD OF EUPOMOTIS AND CENTRARCHUS.

	EUPOMOTIS.				CENTRARCHUS.		
	One inch to two.	Two to three inches.	Three to four inches.	Adults........	One inch and under.	One inch to two.	Adults.
Number of specimens examined......	9	5	2	9	5	1	2
I. MOLLUSCA..................	01	04	45	46	....	....	....
Undetermined......................	....	....	....	07	....	....	....
Gasteropoda..................	01	02	45	33	....	....	....
Amnicola.......................	....	....	....	04	....	....	....
Vivipara	....	....	....	11	....	....	....
Planorbis.......................	....	....	....	01	....	....	....
Physa	....	....	40	....	....	....	....
Acephala........................	....	02	....	06	....	....	....
II. INSECTA..........	60	61	30	20	24	20	91
Undetermined......................	03	03	....	....	...	....	07
1. *Diptera* (larvæ)	52	45	05	01	21	....	06
Chironomus	51	44	05	01	21	....	06
2. *Coleoptera*	....	02	....	02	....	....	....
Hydrophilidæ	....	02	....	02	....	....	....
3. *Hemiptera*..........................	....	....	....	....	....	20	23
Corixa	....	....	....	....	....	20	23
4. *Neuroptera* (larvæ)................	05	11	25	17	03	....	55
Ephemeridæ.................	05	05	25	03	03	....	55
Palingenia........................	....	....	....	03	....	....	....
Agrionidæ..........................	....	06	....	....	....	....	....
Libellulidæ........................	....	....	....	08	....	....	....
Phryganeidæ	....	....	....	02	....	....	....
III. ARACHNIDA.................	....	....	....	....	01	....	....
Hydrachnidæ.......	....	....	....	....	01	....	....
IV. CRUSTACEA	39	35	25	22	75	80	....
Amphipoda (Allorchestes)...........	....	14	25	13	04	....	....
Isopoda (Asellus)......................	....	....	....	09	....	....	....
Entomostraca.......................	39	21	....	....	71	80	....
Cladocera..........................	13	03	....	....	12	....	....
Simocephalus......................	12	01	....	....	12	....	....
Ostracoda	26	18	....	....	21	35	....
Copepoda	....	....	....	....	38	45	09
V. VEGETATION	....	†	....	12	....	....	....
Myriophyllum......................	....	....	....	04	....	....	....
Chara	....	....	....	06	....	....	....
Algæ.................................	....	†	....	02	....	....	....

Only two specimens were examined which could be classed as adults—one three and a fourth inches long, the other smaller. These indicate that the food of full-grown individuals differs from that of the young chiefly in the

addition of considerable quantities of terrestrial and aquatic insects.

The gill-rakers of this species are numerous, long and slender—a fact reflected in the food. Fifteen per cent. of the contents of the stomach of the largest specimen consisted of Cyclops and five per cent. of Chironomus larvæ. Consistently with the small mouth and pointed pharyngeal teeth, no traces of fishes or mollusks were found in the food.

POMOXYS NIGROMACULATUS, Lac. BLACK CROPPIE. LAKE CROPPIE. SILVER BASS. BUTTER BASS.

POMOXYS ANNULARIS, Raf. WHITE CROPPIE. TIMBER CROPPIE. SILVER BASS.

These two species, often not distinguished even by experienced fishermen, agree so closely in food that I have not thought it worth while to treat them separately. In the Illinois and Mississippi rivers they are much the most valuable and important of the family, excepting the black bass. They are nowhere else so abundant in the State, although occurring in the larger rivers generally and in the Great Lakes. The first species is commonest to the north, and the second southward, so far as my observation goes. In the Illinois they are about equally abundant. These fishes are everywhere great favorites, and rank among the most important and promising of our smaller species. They are rarely found in creeks or small ponds, but seem to require deeper water for their maintenance.

The gill-rakers of this species are numerous, long, and finely toothed, constituting the most efficient straining apparatus to be found among the sunfishes. The pharyngeal teeth are sharp, and the mouth is rather wide and considerably enlarged by the lengthening of the lower jaw.

Consistently with the hypothesis concerning the meaning of the gill-rakers which I had already formed from a study of the preceding species, before I came to this, I found that the young continued to feed almost exclusively upon Entomostraca much longer than the other sunfishes. Six specimens between three and four inches long,

had eaten little else than Entomostraca and the larvæ of minute Diptera (Chironomus Corethra). Even full-grown specimens were found eating Cladocera more freely than any other food. As might be inferred from the pharyngeals, not a trace of molluscan food was found in the forty-two specimens examined, while fishes formed nine per cent. of the food of the twenty-seven adults. Most of these were eaten late in the season, when Entomostraca and insect larvæ became less abundant.

Food of the Young.

The smallest specimen, three-fourths of an inch long, had eaten about equal quantities of Cyclops and Simocephalus, with only a few Pleuroxus beside. Three, an inch long and under, had confined their food entirely to Entomostraca and Chironomus larvæ—the latter forming about a fourth of the whole. A third of the Entomostraca were Cyclops, the remainder chiefly Simocephalus.

Six specimens between one and three inches long, differed especially in the introduction of about eighteen per cent. of Corixas and three per cent. of small Ephemerid larvæ. Chironomus larvæ were reduced to seven per cent. The Entomostraca were about equally divided between Cyclops and Cladocera. One specimen taken in July, 1879, from the canal near Ottawa, had taken a large number of Daphnella.

Six specimens between three and four inches long were examined. Eighty-three per cent. of their food was Entomostraca, about three-fourths of this amount being Cyclops, and the remainder nearly all Simocephalus. Twelve per cent. of larvæ of Chironomus and Corethra, three per cent. Corixas and two per cent. larvæ of small Ephemerids were the insect elements. Chydorus, Pleuroxus and Cypris were present in small numbers.

These fifteen young, agreeing so closely in food, irrespective of size, were nevertheless from a variety of situations and dates. All were from the Illinois River, its lakes and tributaries, from Ottawa to Pekin, but ranged in time from June to October of three different years. Six were *P. nigromaculatus*, seven were *P. annularis*, and two were not identified specifically.

Food of the Adults.

An examination of the notes on the twenty-seven adults shows material differences of food at different parts of the year. As all but one were taken from the Illinois River, I have not the means of noting the correspondence of food with locality.

Five specimens taken at Peoria, in March, were found feeding most freely upon Cladocera, which composed fifty-five per cent. of their food. These were chiefly of the two species *Simocephalus vetulus* and *S. americanus*. These little Entomostraca were taken at that time in such quantity as visibly to distend the stomach when seen from the outside, and the immense number of their eggs gave a reddish color to the contents of the alimentary canal. The larvæ of Neuroptera, both "darning-needles" and May-flies (Palingenia), were also eaten in considerable numbers (thirty-nine per cent.). A small Hybopis, a little darter (*Boleosoma maculata*) and an unrecognizable fish were found in these stomachs, making about six per cent. of the food. Only trivial numbers of Entomostraca appear after this time.

Nine specimens, taken in April, likewise at Peoria, were feeding chiefly upon Neuroptera larvæ (eighty-six per cent.), especially upon that almost invaluable element of fish food, the larvæ of *Palingenia bilineata* (sixty-six per cent.). A few larvæ of Gyrinidæ and Dytiscidæ were noted (three per cent.), and a few Corixas also. A *Gammarus fasciatus* and a little Ceratophyllum, etc., were noticed; and also the flower of an elm and the feather of a bird.

A single specimen from Pistakee Lake, in McHenry county, taken in May, gave evidence of a similar reliance upon Neuropterous larvæ (eighty-five per cent.). Here, however, in the absence of Palingenia, Agrions and the larger dragon-flies were resorted to. A little vegetation had been taken with these (*Ceratophyllum demersum* and *Lemna trisulca* ten per cent.), probably by accident, as this lake was full of aquatic plants, and it would hardly have been possible for a fish to catch living food from the water without getting more or less vegetation at the same time. A single Hymenopter—the only land insect

found eaten by this species—was taken from this stomach. A specimen taken in June at Peoria had eaten about equally of minute unrecognized fish-fry and Palingenia larvæ. One caught at Ottawa, in July, had eaten only insects—Corixa twenty-five per cent., Palingenia larvæ seventy-five per cent.

TABLE OF FOOD OF POMOXYS.

	One inch and under.	One inch to three.	Three to four inches.	March, Peoria.	April, Peoria.	May, Pistakee L.	June, Peoria.	July, Ottawa.	October, Peoria.	November, Henry.	Total adults.
No. of specimens	3	6	6	5	9	1	1	1	5	5	27
I. FISHES				06			50		39	28	15
Acanthopteri									10	08	03
Boleosoma				01							
Cycloid				04					11		
Cyprinidæ				04					11		03
Hybopsis				04							01
II. INSECTS	28	28	17	39	90	90	50	100	61	72	73
1. *Hymenoptera*						05					
2. *Diptera* (larvæ)	28	07	12						01	02	01
Corethra		†	03						01		
Chironomus	28	07	09		†	†				02	
3. *Coleoptera* (larvæ)					03	†				03	01
Gyrinidæ					02					03	
Dytiscidæ					01						
4. *Hemiptera*		18	03		01			25			01
Corixa		18	03		01	†		25			01
5. *Neuroptera* (larvæ)		03	02	39	86	85	50	75	60	67	68
Ephemeridæ		03	02	15	72				44		54
Palingenia				15	66		50	75	44	67	52
Agrionidæ				24	14	55					12
Libellulidæ						30					01
Sialidæ (Corydalis)									16		01
III. CRUSTACEA	72	72	83	57	10						12
Gammarus					†						
Entomostraca	72	72	83	55	10						12
Cladocera	49	33	17	55	10						12
Daphniidæ	46	18	17	55	†						12
Lynceidæ	03	01	†								
Sididæ		14									
Ostracoda			01	†	†						
Copepoda	23	39	65		†		†				
IV. VEGETATION				†	†	10	†	†			

Five croppies from Peoria, in October, 1878, and five from Henry, thirty miles above, in November, 1877, indicate that the autumnal food of the species is again differ-

cent. These had eaten, respectively, thirty-nine per cent. and twenty-eight per cent. of small fishes—partly Cyprinidæ and partly undetermined Acanthopteri. The remainder of their food was composed chiefly of Palingenia larvæ. One October specimen had eaten two larvæ of the large "helgramite", *Corydalus cornutus.* Although these fishes were taken directly from the seine, and opened upon the spot, the food in their stomachs did not average more than a fourth of the quantity in those taken in early spring. The weather during both these months was uncomfortably cold, with falling snow, and the food of these specimens probably gives a correct hint of the winter food of the species.

Fourteen of the above were *Pomoxys nigromaculatus* and twelve *P. annularis*—one not having been determined.

Summary of the Family.

For the purpose of a comparative recapitulation of the above data respecting the food of the sunfishes, I have prepared three condensed tables, showing, upon the same page, the food of the different genera in parallel columns. The first table exhibits the food of the youngest specimens, the second, of those of intermediate size, and the third, of those which may properly be regarded as mature.

By an inspection of the first table, it will be seen that the thirty specimens, one inch long and under, representing eight genera, which appear thereon, have eaten little else than Entomostraca and larvæ of Chironomus—these two elements amounting to ninety-three per cent. of the food. The only exception to this rule (that of the rock bass) is apparent rather than real. The large percentage of Neuropterous larvæ appearing under the name of that species is a technical ratio, inserted only for the sake of consistency, being based upon the fact that one of the specimens examined contained no food except a few traces of some indeterminable minute larvæ of that order. The minor differences in the food of the generic groups are doubtless due to differences of locality, and the like. That Ostracoda, for example, were found only

in the stomachs of Centrarchus, is accounted for by the fact that the youngest specimens of this genus were taken from small mud-holes, favorable to the occurrence of Entomostraca of that order. The uniformity of food at this time implies that the selective apparatus of these fishes, whatever its construction, has not yet grown beyond the size of these minute animal forms.

From the second table of one hundred and six specimens we learn that with a general change of food from Entomostraca and Chironomus to larger Crustacea and insects, there appear certain differences—notably the continuance of Entomostraca as the most important element in Pomoxys, and the occurrence of mollusks in Eupomotis and of fishes in Micropterus. It is important to recall, at this point, that Pomoxys has the largest, finest and most numerous gill-rakers of the group—the best *straining* apparatus, in short—that Eupomotis has stout, blunt pharyngeal teeth, and that the black bass have relatively the widest mouths of all. It is also to be noted that the large-mouthed-bass commenced to take fish when an inch and a quarter long, and the small-mouthed species not until it reached a length of two and a half inches.

It will also be observed that Entomostraca are least abundant in the food of the small-mouthed black bass and the rock bass—species found usually in swift and shallow water, when of this size. The importance of water-bugs (Corixa) to the first three species of this table is evident.

From the table of adult food we find that these commencing peculiarities of the preceding table become here more prominent. All the Entomostraca of this table, except insignificant traces, now appear in the food of Pomoxys; the molluscan food of Eupomotis is nearly five times that of any other genus; and the ratios of fish food, running from eighty-six per cent. down to nothing, when arranged in a series, are seen to correspond, with curious exactness, to a series of the species themselves arranged according to the relative sizes of their mouths.

I was disappointed in being unable to find any food characteristics corresponding to such minor differences in the length of the gill-rakers of the anterior arch as ap-

pear in Lepiopomus, Apomotis, etc., on the one hand, and Xenotis and Eupomotis on the other. If such peculiarities exist, they can probably be determined only by taking at one time and place a number of specimens of unlike character in this particular.

While I believe that the generalizations made above will hold good, at least for fishes of similar form and internal structure among the Acanthopteri, I do not wish to be understood as extending them at present beyond this order. Doubtless, while the characters mentioned must assist greatly in determining the food of a species *a priori,* they are not by any means sufficient for this purpose when taken by themselves. The discussion of other features, external and internal, bearing upon this subject must be postponed to a later period of the investigation.

TABLE OF FOOD OF YOUNG CENTRARCHIDÆ. *(One inch and under.)*

	Micropterus pallidus.	Micropterus salmoides.	Amblopltes.	Chænobryttus.	Apomotis.	Lepiopomus.	Eupomotis.	Centrarchus.	Pomoxys.	Undetermined.	Total.
Number of specimens	5	..	3	2	1	5	..	5	3	6	30
I. INSECTS	....	..	39	....	02	37	..	24	28	....	17
1. *Diptera* (larvæ)	....	..	05	....	01	37	..	21	28	....	13
Chironomus	....	..	05	....	01	37	..	21	28	....	13
2. *Hemiptera*	....	..	..	....	01	..	..	..	..	....	..
Corixa (young)	....	..	..	....	01	..	..	..	..	....	..
3. *Neuroptera* (larvæ)	....	..	34	....	..	..	..	03	..	....	04
II. ARACHNIDA (Hydrachna)	....	..	..	....	..	04	..	01	..	....	01
III. CRUSTACEA	100	..	61	100	98	59	..	75	72	100	82
Tetradecapoda	07	..	..	....	..	02	..	04	..	....	02
Entomostraca	93	..	61	100	98	57	..	71	72	100	80
Cladocera	87	..	58	70	03	37	..	12	49	88	53
Ostracoda	....	..	..	....	..	..	..	21	..	†	04
Copepoda	06	..	03	30	95	20	..	38	23	22	23

TABLE OF FOOD OF YOUNG CENTRARCHIDÆ. *(One to four inches.)*

	Micropterus pallidus.	Micropterus salmoides	Ambloplites.	Chænobryttus.	Apomotis.	Lepiopomus.	Eupomotis.	Centrarchus.	Pomoxys.
Number of specimens	12	24	5	8	10	16	16	3	12
I. FISHES	15	06	....	....	....	....	....	....	....
II. MOLLUSCA	....	....	....	....	....	....	08	....	....
III. INSECTA	72	67	98	61	78	51	56	67	22
1. *Diptera* (larvæ)	01	03	02	18	09	28	44	04	09
Chironomus	01	01	02	15	07	28	43	04	08
2. *Coleoptera*	....	02	01	....	09	†	01	....	....
Terrestrial	....	....	....	....	07	....	....	....	....
Aquatic	....	02	01	....	02	†	01	....	....
3. *Hemiptera* (aquatic)	50	50	78	10	16	11	....	23	11
Corixa	49	50	76	10	16	11	....	23	11
4. *Neuroptera*	14	12	....	33	33	11	10	37	02
Ephemeridæ	14	08	....	08	29	05	08	37	02
Odonata	....	04	....	19	04	06	02	....	....
IV. ARACHNIDA	....	....	....	....	....	07	....	....	....
V. CRUSTACEA	13	26	02	38	22	32	36	33	78
Decapoda	....	....	....	....	01	....	....	....	....
Tetradecapoda	....	23	01	....	04	....	08	....	....
Entomostraca	13	03	01	38	17	32	28	33	78
Cladocera	07	03	....	29	09	08	08	....	25
Ostracoda	....	....	....	....	03	03	20	12	01
Copepoda	06	†	01	09	05	20	....	21	52
VI. POLYZOA	....	....	....	....	....	05	....	....	....
VII. LUMBRICUS	....	....	....	....	....	04	....	....	....
VIII. VEGETATION	....	01	....	01	....	01	....	....	....

TABLE OF FOOD OF ADULT CENTRARCHIDÆ.

	Micropterus pallidus.	Micropterus salmoides.	Ambloplites.	Chænobryttus.	Apomotis.	Lepiopomus.	Xenotis.	Eupomotis.	Centrarchus.	Pomoxys.
Number of specimens	14	3	4	6	8	24	6	9	2	27
I. FISHES	86	38	15	46	36	01	07	....	....	15
Acanthopteri	15	....	....	....	....	01	....	....	....	03
Dorysoma	58	....	....	....	....	....	....	....	....	....
Cyprinidæ	06	....	....	....	12	....	....	....	....	03
Siluridæ	07	....	....	....	....	....	....	....	....	....
II. MOLLUSCA	....	....	....	....	....	10	08	46	....	....
Gasteropoda	....	....	....	....	....	10	04	33	....	....
Acephala	....	....	....	....	....	†	04	06	....	....

TABLE OF FOOD OF ADULT CENTRARCHIDÆ—Continued.

	Micropterus pallidus.	Micropterus salmoides.	Amblophtes.	Chænobryttus.	Apomotis.	Lepiopomus.	Xenotis.	Eupomotis.	Centrarchus.	Pomoxys.
Number of specimens...	14	3	4	6	8	24	6	9	2	27
III. INSECTA.	†	....	52	54	42	45	82	20	91	73
1. *Hymenoptera* (ants)..	....	....	....	....	....	....	....	....	07	....
2. *Diptera* (larvæ)......	....	....	06	....	....	01	37	01	06	01
Chironomus..........	....	....	....	...	....	....	37	01	06	....
3. *Coleoptera*..........	....	....	03	10	05	13	06	02	....	01
Terrestrial	....	....	....	10	....	06	04	....	....	....
Aquatic..............	....	....	03	....	05	....	....	02	....	01
4. *Hemiptera* (Corixa)..	†	....	....	18	03	02	17	....	23	01
5. *Orthoptera*	....	....	....	....	....	02	....	....	....	....
6. *Neuroptera*..........	†	....	42	25	33	24	16	17	55	68
Ephemeridæ.........	....	....	21	25	27	03	....	04	55	52
Palingenia	....	....	....	25	01	02	....	03	....	52
Odonata	....	....	06	....	02	12	....	08	....	13
Sialidæ	....	....	....	....	04	06	....	....	....	01
Phryganeidæ.........	....	....	15	....	....	03	08	01	....	....
IV. ARACHNIDA	....	....	†	....	....	....	....	....	....	....
V. CRUSTACEA	07	62	31	†	20	18	03	22	09	12
Decapoda..............	07	62	31	....	20	01	....	....	....	....
Tetradecapoda.........	....	....	....	....	....	17	03	22	....	....
Entomostraca	...	....	....	†	....	†	....	....	09	12
Cladocera............	....	....	....	†	....	†	....	....	....	12
Ostracoda............	....	....	....	....	....	†	....	....	....	†
Copepoda.	....	....	....	....	....	....	....	....	09	†
VI. POLYZOA.........	....	....	....	....	..	02	....	....	....	....
VII. VEGETATION ...	†	....	02	....	02	24	....	12	....	†
Miscellaneous	07	....	....	....	...	....	....	....	....	....

HAPLOIDONOTUS GRUNNIENS, Raf. SHEEPSHEAD. GRUNTING PERCH.

This species is abundant in Lake Michigan and the larger rivers, occurring in the smaller streams rarely, at periods of exceptionally high water. It is sometimes eaten, but is regarded usually as unfit for food.

But six of the twenty-five specimens studied were young, and the smallest of these, from the Ohio R., in September, was an inch and an eighth in length. Seventy-five per cent. of its food was larvæ of Chironomus and twenty-five per cent. larvæ of *Palingenia bilineata*. Besides the usual indications that the food of the very young is made up of minute animals, we see here evidence that this species seeks its food from the first upon the bottom.

In a specimen two inches long, the Chironomus larvæ fell to fifteen per cent., while the Palingenia larvæ rose to eighty per cent., and other Ephemerids and Cyclops made up the remainder of the food.

Four specimens, also from the Ohio, at Cairo, from two to four inches long, were found to have recently fed upon Ephemerid larvæ and larvæ of aquatic beetles, Gyrinidæ and Hydrophilidæ, in about equal quantities. Only five per cent. of their food was Chironomus.

Sixteen individuals of medium size were taken from the Illinois and Ohio rivers, in April, June, September and October of four different years. There was nothing in the contents of these stomachs to indicate any difference in food resulting from these differences of date and situation. The food, on the contrary, was remarkably simple and uniform, consisting chiefly of the larvæ of Neuroptera (eighty-four per cent.), of which *Palingenia bilineata* formed altogether the most important part (seventy-six per cent.)—the remaining eight per cent. being dragon-flies. A single small sucker (Catostomidæ), a few mollusks (Planorbis, young Unios and thin-shelled Anodontas), and some Aselli complete the brief dietary of this group.

It is not until we examine the food of full-grown specimens that we wholly appreciate the utility of the enormous crushing pharyngeal jaws with their pavement teeth, found in this species. The entire food of the three large specimens examined, taken at Peoria, in April and October, proved to consist of mollusks only, including forty-six per cent. of the thick and heavy water snail, *Melantho decisa,* whose shell probably no other fish in our rivers could break. Cyclas, Anodonta and indeterminable Gasteropoda composed the remainder of the food.

ON THE FOOD OF YOUNG FISHES.

By S. A. FORBES.

I cannot learn that anything has been recorded respecting the food of young fishes in this country,* nor have I been able to find anything upon this subject in such part of the ichthyological literature of Europe as is accessible to me. From the lack of all mention of the use of Entomostraca as the food of young fishes in the general review of the relations of these Crustacea to organic nature given by Gerstaecker in Bronn's Thier-Reich† I infer that whatever systematic investigation the subject may have received, the results have not attracted any general attention.

This seems a surprising fact when one considers the vast amount of labor which has been expended upon this class of animals, and reflects for a moment upon the interest to science and to practical fish-culture of a knowledge of the food resources of fishes and of the competitions of the various species in the search for subsistence.

Although I cannot yet treat this subject as fully as it deserves, the results of such study as I have been able to make, during the past season, of the contents of the stomachs and intestines of small specimens, seem to justify this preliminary notice.

It was early apparent, in the course of the investigation, that the food of many fishes differs greatly according to age; and it was soon found that the life of most of our fishes divides into at least two periods, and of many into three, with respect to the kinds of food chiefly taken. Further, in the first of these periods a remarkable similarity of food was noticed among species and families whose later food-habits are widely different.

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* Perhaps exception should be made of a note relating to the occurrence of diatoms in the stomachs of two young whitefishes, published in the appendix to the Report of the U. S. Fish Commissioner for 1872-3, p. 57.

† Classen und Ordnungen des Thier-Reichs, Band V, Abtheilung 1, ss. 750 u. 1057.

The full-grown black bass, for example, feeds principally on fishes and crawfishes, the sheepshead on mollusks, the gizzard-shad on mud and Algæ, while the catfishes are nearly omnivorous; yet these are all found to agree so closely in food when very small that one could not possibly tell from the contents of the stomachs which group he was dealing with.

It is my purpose in this paper to give what facts I have relating to the food of our fresh-water species during this first period of the fish's life. These facts were derived from the examination of one hundred and twenty-six specimens, ranging from three-eighths of an inch in length up to an inch and a half, and in a few cases to two and three inches. These specimens belong to twenty-four genera and represent eleven families. In two or three genera none were obtained small enough to be regarded as belonging strictly to this first food-period, but the earliest food is nevertheless plainly inferable; and the general distribution and variety of the species studied is such that I think the main conclusions will be found to stand the test of full investigation. As the first period is evidently much shorter with some species than with others, and doubtless varies in the same species according to situation and circumstances generally, of course no common limit of size could be set up, but the smallest specimens of each species were selected until a size was reached where a marked difference of food appeared.

Acanthopteri.

Although the young Acanthopteri have already been discussed in the preceding paper on the food of that group, it will be convenient to review the facts concerning these young fishes for the purpose of comparing their food with that of the other orders.

The food of six *common perch* (*Perca americana*), from an inch to an inch and a quarter long, consisted wholly of Entomostraca and larvæ of Chironomus—eight per cent. Chironomus, fifty-two per cent. Cladocera and forty per cent. Copepoda.

No very small Labracidæ were found, the youngest being a Morone an inch and a quarter long. Half of the food of this consisted of Entomostraca (chiefly Cladocera), and the other half was minute gizzard-shad.

A group of forty-three sunfishes (Centrarchidæ), from five-eighths of an inch to two inches long, was made up as follows:—of five specimens of Micropterus under three-fourths of an inch long, two Ambloplites of the same size, two of Chænobryttus from seven-eighths of an inch to one inch, one of Apomotis an inch in length, nine of Lepiopomus from an inch to an inch and a fourth, nine of Eupomotis from one and a half to two inches, five of Centrarchus one inch and under, four of Pomoxys from three-fourths of an inch to an inch and a half, and six indeterminable specimens, probably Lepiopomus, from seven-sixteenths to five-eighths of an inch long. Ninety-six per cent. of the food of these forty-three specimens consisted of Entomostraca and larvæ of Chironomus—seventy of the first and twenty-six of the second—the trivial remainder consisting of Neuroptera larvæ and young Amphipoda with traces of water mites, Corixas and mollusks (the last in Eupomotis). The Entomostraca were forty-two per cent. Cladocera, nineteen per cent. Copepoda and nine per cent. Ostracoda.

A single Haploidonotus an inch and an eighth in length, had eaten Chironomus larvæ (seventy-five per cent.) and larvæ of *Palingenia bilineata.*

Esocidæ.

I did not have the good fortune to obtain any young of the common pike, and can only report on the food of a single *Esox salmoneus* an inch and a fourth in length. This specimen, taken at Pekin, Ill., on the 2d of June, had already begun its life labor of the elimination of little fishes, these making about two-fifths of its food. The remainder consisted of Crustacea, composed about equally of young Amphipoda, Daphniidæ and Lynceidæ. The presence of so large a quantity of these minute Entomostraca in the stomach of a pickerel of this size, is sufficient evidence that they form the principal part of its food at an earlier age.

Clupeidæ.

We come next to twelve specimens of the *gizzard-shad* (Dorysoma), whose minute fry swarm in countless numbers in the waters of our larger rivers in midsummer. These were taken in June and July, from the Illinois R., from Ottawa to Peoria. The smallest of the group were twenty mm. long by two mm. wide—as slender as cyprinoids and nearly cylindrical, although the adult is a high, thin fish. I was greatly interested by the discovery that the maxillaries of these smallest specimens are provided with teeth—a single row of nine or ten on the lower edge—although the mouth of the adult is entirely toothless and smooth. The internal structure also differs remarkably from that of the adult, especially in the much greater simplicity of the digestive apparatus. In a young gizzard-shad seven-tenths of an inch long by one-tenth high, the intestine was found to pass from the anterior end of the stomach to the vent with only one short forward turn of about a fourth the length of the body cavity, made a little way behind the stomach. Although the mucous surface of the intestine was at this time very rugose, showing a commencing complication of the digestive system, there was no trace of pyloric cœca. The intestine was filled with Cypris, Chydorus, Alona, Cyclops, etc.

On the other hand, in a fish three and three-fourths inches long, showing the general characters of the adult, the intestine passed upward and backward from its origin, running without flexure the whole length of the body cavity (this part being covered with an immense number of pyloric cœca), then turned forward to the stomach, ran back from there about one-third of the way to the vent, then turned forward and ran a tortuous course beneath the stomach to the pericardial membrane and back again, also tortuously, two-thirds of the way to the vent. From this point it ran forward again to the stomach, and crossing to the left side, ran repeatedly backward and forward in the posterior part of the body cavity, making seven turns between the stomach and vent before opening, thus extending, in all, about eight times the length of the perivisceral cavity. This intestine was

well filled with mud with only a slight sprinkling of unicellular Algæ.

Much as these young resemble young Cyprinidæ, they can be easily distinguished from them by the very long anal fin; and from the brook silversides (Labidesthes), to which they bear some superficial resemblance, by the absence of a spinous dorsal.

These twelve fishes, all under two inches in length, had eaten about ninety per cent. of Entomostraca, two per cent. of Chironomus larvæ, and for the remainder, Algæ. The Crustacea were about equally Cladocera and Copepoda. Among the former were *Daphnia pulex*, *Simocephalus americanus*, *Ceriodaphnia dentata*, Bosmina, Chydorus and Alona. In a specimen three-quarters of an inch long which I took from the stomach of a *Morone interrupta*, I found a few specimens of *Leptodora hyalina* (?) Lillj. The Copepoda were all Cyclops, so far as recognizable.

Cyprinidæ.

A single minute minnow, three-eighths of an inch long, which I could not determine specifically, had eaten Daphnids (twenty-five per cent.) and Chironomus larvæ..

The specimens of the common *chub minnow* (*Semotilus corporalis*), ranging from five-eighths inch to one inch, indicate somewhat doubtfully an exception to the general rule respecting the early food of fishes. Only seven per cent. of their food was Entomostraca, and the whole remainder consisted of filamentous Algæ. It should be noted, however, that twenty per cent. of the food of the smallest specimen, which was five-eighths of an inch long, was Cyclops, and it may be that Semotilus lives wholly on Entomostraca at first, merely changing its habit earlier than most of its allies.

Two specimens of *Notropis*, an inch and a half in length had eaten nothing but Daphnids.

Catostomidæ.

Thirty specimens, representing five genera of this peculiar family, were studied. A very curious feature of the food of the young is the frequent dependence of suckers

of considerable size—six inches long or more—upon food more trivial than Copepoda or Lynceidæ; viz., upon rotifers, Protozoa and unicellular Algæ. While only such Protozoa were found as are furnished with firm tests or carapaces, yet the abundance of Difflugia and Arcella in the intestines of these fishes leaves little doubt that the more perishable Protozoa must also be taken in considerable quantity. It is an interesting fact that even here the smallest specimens were found feeding on Entomostraca only, and it is therefore possible that these form the first food of the family.

Ten specimens of the *stone-roller* (*Hypentelium nigricans*), ranging from one and three-eighths to three inches represent two dates and localities. The four smallest, none larger than an inch and three-fourths, were taken from the lower Fox, July 9, 1879. The others were obtained from Mackinaw Cr., in Woodford Co., Ill., in the latter part of August. The situations were similar, both streams being swift and rocky where these fishes were caught. Their food was chiefly the larvæ of Chironomus (ninety per cent.), the remaining tenth being principally made up of Alona (six per cent.). Ostracoda, Copepoda, and Algæ each made about one per cent. of the food. The Algæ were mostly diatoms and desmids, Closterium being especially common. Many Difflugia and Arcella were also found in these fishes.

We trace in this a remarkable resemblance to the food of the darters, which, it will be remembered, frequent similar situations. Lacking the sucking mouth of Hypentelium, they do not take Protozoa or unicellular Algæ, but in other particulars agree closely with this species. This curious fish is peculiar among the suckers in the unusual development of the pectoral fins—a distinguishing feature of the darters likewise—doubtless related, in both cases, to the constant struggle with a swift current. We may also remark the darter-like glow of color in the young of this species—a very peculiar distinction among the Catostomidæ. This is one among many facts which indicate that exposure to light has great primary effect on the color of fishes—an effect often suppressed.

through natural selection, by secondary influences, but manifesting itself where these are not brought into play.

This species is in marked *contrast* with the darters, not only in the rapidity of its growth and the ultimate size attained, but in the form and size of the head, which in the darters is small and pointed, but in these fishes is unusually large, square and strong.

The principle of adaptation has here resulted in a different line of development. While the little Etheostomatidæ have become fitted to slip and pry about beneath the stones for their food, Hypentelium has acquired the power of rolling the stones before it. As it grows larger, it resorts, of course, to deeper water, but always prefers the rocky reaches of the stream. The moulding power of natural selection could scarcely have a better illustration than that afforded by the adaptive characters, both similar and dissimilar, of these two widely separated groups of fishes.

A single specimen of *black sucker* (*Minytrema melanops*) was too large properly to come within this group; but, although six inches long, most of its food was Cyclops (eighty per cent.). Other items were Alona, Difflugia, Closterium and very young Unios.

Four *chub-suckers* (*Erimyzon sucetta*), two of which were three-fourths of an inch, and two an inch and a quarter long, differed greatly in food from the foregoing. The two smaller specimens, from Long L., near Pekin, taken June 2, 1880, had eaten only Cladocera, with a trace of water mites. Chydorus was the principal element of their food (eighty per cent.), but Pleuroxus, Alona and *Scapholeberis mucronata* were also present. In the two larger specimens, locality and date unknown, a surprising number and variety of the minutest animal and vegetable forms were found. Squamella, Anuræa of several species, *Rotifer vulgaris* and other Rotifera; Difflugia and Arcella* among the Protozoa; Chroöcoccus, Closte-

* Slides of the food of this genus and Myxostoma were submitted to Dr. Jos. Leidy, of Philadelphia, and Prof. W. S. Barnard, of Cornell University, N. Y., and these gentlemen kindly sent me the following names of Rhizopoda as occurring therein: From Prof. Barnard, *Difflugia acuminata, pyriformis, constricta* and *globosa;* from Dr. Leidy, *D. pyriformis, acuminata, globulosa, lobostoma* and *Arcella vulgaris* and *discoides*

rium, Cosmarium, Staurastrum and various diatoms among the Algæ, were the principal genera. A minute Agrion larvæ, a very young Amphipod, and larval Copepoda (nauplii), were the only other kinds recognized. It was obviously impossible to make any estimate of the ratios of such minute and varied objects occurring in such great quantity, and I have contented myself with a simple enumeration.

A specimen three inches long, from Peoria Lake, in October, had eaten only Copepoda (Canthocamptus) with a trace of Chironomus larvæ.

Ten specimens of *red-horse* (Myxostoma), varying in length from an inch to two and three-fourths, taken in July and August, from the Fox and Illinois rivers and from Mackinaw Cr., show no important differences of food.

In the smaller specimens, taken from the Fox and Illinois, Entomostraca, especially Cyprids, were relatively more important, sometimes constituting nearly the whole food; but no attempt was made to fix precise ratios. In the four larger specimens from Woodford Co., tests of Difflugia were estimated to form eighty-five per cent. of the contents of the intestines. These specimens were taken one at a time, several miles apart, along a rocky part of the stream. Besides the species of Difflugia and Arcella given in the foot note, various desmids and diatoms were abundant, with filamentous Algæ, rotifers (Squamella and *Rotifer vulgaris*), Cyclops, Alona, Pleuroxus and water mites, Chironomus and other Diptera larvæ, some indeterminable vegetable matter and a single Thrips (Hemiptera). The small percentage of Chironomus larvæ shows that this species has not the habit of the stone-roller.

Two specimens of the *common sucker* (*Castostomus commersonii*), six inches and six and three-fourths in length, taken from Mackinaw Cr., in August and June, had eaten food so similar to that of the preceding genus that detailed description is unnecessary.

Two specimens of the commonest *buffalo-fish* (*Ichthyobus*), seven-eighths of an inch long, had eaten most freely

of unicellular Algæ (sixty-three per cent.), of which only Protococcus and Closterium were recognized. Specimens of Anuræa were reckoned at twenty-seven per cent., and the remainder of the food consisted of Copepoda and Cladocera. These specimens were taken from the Illinois R., in early June.

Four *carp-suckers* (Carpiodes), seven-eighths inch to two inches long, taken from the Illinois and from Clear L., in Kentucky, had fed like the preceding genus, except that the Entomostraca were in larger quantity (forty-eight per cent.), and included a number of Ostracoda, while the rotifers were comparatively few. The Daphniidæ of the Illinois R. specimens were nearly all *Scapholeberis mucronata.* Canthocamptus in trivial numbers was also found in a single specimen.

Reviewing the food of these thirty young suckers, we see that they differ from the other families studied in the larger food-resources open to them; for, while the structure of their mouths does not prohibit their taking Entomostraca, it enables them to draw upon the multitudes of minute organisms found upon the bottom. Evidently they have no means of selecting such microscopic structures from the mud in which these most frequently rest, and considerable quantities of dirt are consequently often found in the intestines; but from the "richness" of the contents I infer that they doubtless have the power of distinguishing mud containing a large percentage of organic matter from relatively barren portions.

Siluridæ.

Numerous specimens of the young of this family show that, notwithstanding its many peculiarities of structure and habit, it is no exception to the general rule respecting the food of the young. The smallest of these specimens were from a little school of minute fry, taken in June from the friendly protection of an old oyster-can in the Illinois R. These little creatures were colorless and seemingly almost helpless, and only three-eighths of an inch in length. They had already begun to eat, however, and their stomachs were well filled with Cyclops and a

few Daphnids and Chironomus larvæ. These were certainly Amiurus, but it was of course impossible to tell the species.

Other specimens of this genus, making thirteen in all, none longer than an inch and five-eighths, were obtained from various places on the Illinois, and from mud-holes in the Mississippi bottoms, in Union Co. These thirteen individuals were feeding almost wholly on Entomostraca and larvæ of Chironomus, the latter composing seventy-four per cent. and the former eighteen per cent. of their food. Twenty-two per cent. of Cladocera include *Simocephalus americanus* and *S. vetulus,* Ceriodaphnia and *Macrothrix laticornis,** Jur., a species not hitherto reported from this country. Among the Lynceidæ (ten per cent.) I recognized Chydorus, *Pleuroxus dentatus,* Alona and *Eurycercus lamellatus*, and among the Ostracoda a species of Candona answering precisely to the description of *Candona bifasciata,* Say. A few young Amphipoda and a few unknown insects' eggs account for the remainder of the food.

Six specimens of *Noturus sialis,* varying in length from seven-eighths of an inch to an inch and a quarter, differed from the foregoing in the much larger proportion of Chironomus larvæ (forty-one per cent.) and in the twenty-six per cent. of young *Allorchestes dentata*—eaten by the larger specimens. These had also taken seven per cent. larvæ of Ephemeridæ. Those under an inch in length were peculiar only in the large ratio of Chironomus larvæ (sixty-five per cent.), a fact probably indicating that this species seeks its food chiefly on the muddy bottoms.

No specimens of the other genera of catfishes were taken small enough to show their earliest food, but so far as can be judged from the food of four specimens of Ictalurus, from two and a half to three and a half inches long, the other genera will not be found to differ especially from the foregoing.

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* Possibly this is not the species cited, but a careful comparison with the description and figures in Lilljeborg's "Crustacea ex Ordinibus Tribus," etc., failed to show any difference.

Amiidæ.

A single dog-fish (Amia), one and three-fourths inches long, taken in June, had eaten seventy per cent. of Entomostraca—about equally Copepoda and Cladocera—and two per cent. of larvæ and pupæ of Chironomus. A few young Allorchestes and some Corixas complete the brief list.

Several specimens of Amia under one inch in length, whose anatomy I studied three years ago, I remember to have had their intestines packed with Entomostraca.

Lepidosteidæ.

Here also I shall have to content myself with such hints of the food of the young as are given by two or three specimens, as the youngest are not yet common enough in our collections to supply more material for a study of their food. One of the two smallest gars examined, an inch and a fourth in length, taken in June, near Peoria, had filled itself with *Scapholeberis mucronata,* and the other had taken only a minute fish. A specimen two inches long and only an eighth of an inch in depth, furnished a striking illustration of the voracity of this terror of our streams, as its stomach contained sixteen minute Cyprinoids.

Summary.

A sufficient recapitulation of the foregoing data is afforded by the appended table of the food of the different genera. It may be worth while to say that all the material upon which the foregoing statements rest, as well as all that used in the preceding paper, has been carefully preserved, and may be seen at any time by those interested, at the State Laboratory of Natural History.

The general conclusion from these observations is the supreme importance of Entomostraca and the minute aquatic larvæ of Diptera as food for nearly or quite all of our fresh-water fishes—a conclusion that gives these trivial and neglected creatures, of whose very existence the majority of the people are scarcely aware, a prominent place among the most valuable animals of the State,

for without them all our waters would be virtually depopulated. Other facts of eminent interest thus brought to view are the magnitude and intensity of the competition for food among the young of all orders of fishes, where a stream is fully stocked, and the injurious character of such a species as the shovel-fish, which feeds on Entomostraca throughout its life. It is probable that all fishes which are not especially adapted to the food requirements of the more valuable fishes, are hurtful to them, because they limit the food available for the young. The sunfishes, whose shape protects them from many enemies, and the catfishes, with their armor of poisoned spines, are instances in point. While their young compete with the young bass and wall-eyed pike for food, they do not furnish the latter any important food resource in later years. On the other hand, such species as the herbivorous minnows and the cylindrical suckers, which depend upon Entomostraca to a less extent when young, or take up other food at a relatively early period, are those which seem to promise best as food for the higher fishes.

It is a curious corollary from the above reasoning that a prolific species having an abundant food supply, and itself the most important food of predaceous fishes, may, by extraordinary multiplication, so diminish the food of the young of the latter as to cause, through its own abundance, a serious diminution of the numbers of the very species which prey upon it. To put this statement into more concrete form, it is not certain that the excessive increase of the gizzard-shad, for instance, would be a benefit to the black bass and pike-perch which feed so largely upon it. In fact, it is clear that the great overstocking of a stream with gizzard-shad would, by eventually reducing the supply of Entomostraca, cause a corresponding reduction in the numbers of all the species of that stream by starvation of the young; and this decimation, applying to all in the same ratio, would take effect upon the *ordinary* number of the other species, but upon the *extraordinary* number of the gizzard-shad—would reduce the other species below the usual limit, but might not even cut off the *excess* of the shad above that limit. Conse-

quently, important as is the supply of food fishes for the predaceous species, it is not less important that the predaceous species should be supplied to eat up the food. Here, as elsewhere, only harm can come from an imperfect balance of the forces of organic nature, whether the excess be upon one side or the other.

In the effort to increase the valuable fishes of a lake or stream, it is not sufficient that the food of these species should be increased alone, but at the same time special measures must be taken to secure a corresponding multiplication of the predaceous fishes themselves, otherwise precisely the reverse result may be produced from that intended.

As a further illustration of some of the practical bearings of these facts. it may be noticed that the free access of fishes to the ponds, lakes and marshes connected with a sream is a matter of the highest importance. Running water is relatively destitute of Entomostraca, and hence fishes denied access while breeding to slow or stagnant water in which Entomostraca abound, have no chance to multiply. The condition of fish life in the lower Fox R. will illustrate this point. This stream takes its rise in the numerous lakes of northwestern Illinois and southern Wisconsin, but in its lower course has few branches and no stagnant waters draining into it. Its own current is swift and much of its bed is rocky, while the vast expanse of water of which it forms the outlet prevents any great oscillations of its level with the consequent flooding of adjacent lands. This part of the stream is therefore peculiarly unfit for breeding purposes, and we should expect few fish to maintain themselves in it if denied access to the immense and teeming breeding grounds of the upper part of the river. Such access is effectually cut off by several dams, unprovided with fishways, which have been thrown across the stream. A fish which enters the river from above therefore cannot get back to breed—a fact which must unfavorably affect the number of fishes in both river and lakes, and is apparently one cause of an unusual scarcity of game fishes in that stream.

TABLE OF FOOD OF YOUNG FISHES.

	Perca.	Morone.	Centrarchidæ*	Haploidonotus.	Esox.	Dorysoma	Cyprinidæ, sp.	Semotilus.	Notropis.
Number of specimens.....	6	1	43	1	1	12	1	3	2
Size in inches...............	1@ 1¼	1¼	⅝@ 2	1⅛	1¼	½@ 1¾	⅜	⅝ @1	1⅓
KINDS OF FOOD.	Ratios in which each element of food was found.								
I. FISHES..................	....	50	....	....	40	....	....	....	....
Dorysoma....................	....	50	....	....	....	....	....	....	....
II. MOLLUSKS............	....	....	†	....	....	....	....	....	....
III. INSECTS...............	08	....	28	100	....	02	75	....	....
1. *Diptera* (larvæ)...........	08	....	26	75	....	02	75	....	....
Chironomus...............	08	....	26	75	....	02	75	....	....
Corethra..................	....	....	....	....	....	†	....	....	....
2. *Hemiptera* (young)........	....	....	†	....	....	....	....	....	....
Corixa....................	....	....	†	....	....	....	....	....	....
3. *Neuroptera* (larvæ)........	....	....	02	25	....	....	....	....	....
Ephemeridæ..............	....	....	....	25	....	....	....	....	....
Palingenia..............	....	....	....	25	....	....	....	....	....
IV. HYDRACHNIDÆ.......	....	....	†	....	....	....	....	....	....
V. CRUSTACEA............	92	50	72	....	60	90	25	07	100
Amphipoda (young).........	....	....	02	....	20	....	....	....	...
Entomostraca................	92	50	70	....	40	90	25	07	100
Cladocera................	52	40	42	....	40	42	25	....	100
Sididæ..................	....	....	02	....	....	....	....	....	....
Daphniidæ..............	50	....	36	....	20	34	25	....	100
Lynceidæ...............	02	....	04	....	20	04	....	....	....
Leptodoridæ............	....	....	....	....	....	02	....	....	....
Ostracoda.................	....	....	09	....	....	†	....	....	....
Copepoda..................	40	10	19	....	....	48	....	07	....
VI. ALGÆ	....	....	....	....	....	08	....	93	....

* For detailed tables of the food of the young of this family see the preceding paper on the food of the Acanthopteri.

TABLE OF FOOD OF YOUNG FISHES—Continued.

	Hypentelium.	Erimyzon.	Myxostoma.	Ichthyobus.	Carpiodes.	Amiurus.	Noturus.	Amia.	Lepidosteus	TOTAL.
Number of specimens....	10	4	10	2	4	13	6	1	2	126
Size in inches...........	1⅜ @3	¾@ 1¼	1@ 2¾	⅞	⅞@ 2	⅜@ 1⅝	⅞@ 1¼	1¾	1¼	
KINDS OF FOOD.	Ratios in which each element of food was found.									
I. FISHES.............	....	....	...	....	....	....	....	....	50	...
II. INSECTS..........	90	11	†	....	....	22	58	25	....	...
Eggs.	....	04	....	....	....	....	....	....	....	...
1. *Diptera* (larvæ).......	90	....	†	....	....	18	41	10	....	...
Chironomus............	90	....	†	....	....	16	41	10	....	...
2. *Coleoptera* (larvæ)	....	....	....	....	....	....	10	....	....	...
3. *Hemiptera*...........	†	†	†	....	....	...	...	15	....	...
Corixa	....	....	....	....	....	....	....	15	....	...
4. *Neuroptera* (larvæ)....	†	07	..	....	....	....	07	....	....	...
Ephemeridæ..........	†	04	....	....	....	....	07	....	....	...
III. HYDRACHNIDÆ...	†	03	†	....	....	....	....	....	....	...
IV. CRUSTACEA.......	09	51	†	10	48	78	40	75	50	...
Amphipoda (young)......	....	†	....	....	...	04	20	05	....	...
Entomostraca	09	50	†	10	48	74	15	70	50	...
Cladocera.............	07	49	†	05	23	22	06	35	50	...
Daphniidæ..........	01	02	....	....	23	11	....	35	50	...
Lynceidæ...........	06	47	†	....	....	10	06	....	.....	...
Ostracoda.............	01	01	†	....	15	12	....	....	....	...
Copepoda.............	01	†	†	05	10	40	09	35	....	...
V. ROTIFERA.	....	....	†	27	†	....	....	....	....	...
VI. PROTOZOA........	†	15	†	....	†	....	....	....	....	...
VII. ALGÆ	01	20	†	63	52	...	02	....	....	...

THE FOOD OF BIRDS.

BY S. A. FORBES.

Excluding the inhabitants of the great seas, birds are the most abundant of the Vertebrata, occupying in this great subkingdom the some prominent position that insects do among invertebrate animals. These two classes thus constitute exceptions to the general rule that the higher and more active animals of each group are the less abundant—a fact doubtless largely due to the immense advantage given them by their power of flight. It is this which, by making migration possible, enables birds to choose their climates and their seasons—thus avoiding, in a great measure, one of the most destructive checks upon the multiplication of animals. Their disproportionate number, their universal distribution, the remarkable locomotive power which enables them readily to escape unfavorable conditions, and their immense activity and higher rate of life, requiring for their maintenance an amount of food relatively enormous, give to birds in their relation to the pursuits and interests of man a significance which only here and there one seems ever fully to have realized. A few figures will illustrate and enforce this proposition.

The careful estimates of three ornithologists and experienced collectors give, as an average of the whole bird-life of Illinois, three birds per acre during the six summer months. That is to say, if all the birds of the year, except the swimmers, were concentrated in these six months, equally distributed throughout them and equally scattered over the State, we should have three birds on every acre of land. It is my opinion that about two-thirds of the food of birds consists of insects, and that this insect food will average, at the lowest reasonable estimate, twenty insects or insects' eggs per day for each individual of these two-thirds, giving a total for the year of seven thousand two hundred per acre, or two hundred and fifty billions for the State—a number which, placed one to each square inch of surface, would cover an area of forty thousand acres.

Estimates of the average number of insects per square yard in this State gives us, at farthest, ten thousand per acre for our whole area. On this basis, if the operations of the birds were to be suspended, the rate of increase of these insect hosts would be accelerated about seventy per cent., and their numbers, instead of remaining year by year at the present average figure, would be increased over two-thirds each year. Anyone familiar with geometrical ratios will understand the inevitable result. In the second year we should find insects nearly three times as numerous as now, and, in about twelve years, if this increase were not otherwise checked, we should have the entire State carpeted with insects, one to the square inch over our whole territory. I have so arranged this computation as to exclude the insoluble question of the relative value of birds and predaceous or parasitic insects, unless we suppose that birds eat an undue *proportion* of beneficial species.

This is intended only as an illustration of the great power of birds for good or evil, and not as a prediction of the consequences of their total destruction. These consequences would not be by any means so simple, but would apparently be fully as grave.

Let us take another view of this matter. According to the computation of our first State Entomologist, Mr. Walsh, the average damage done by insects in Illinois amounts to twenty million dollars a year. These are large figures, certainly; but when we find that this means only about fifty-six cents an acre, we begin to see their probability. At any rate, few intelligent farmers or gardeners would refuse an offer to insure complete protection, year after year, against insects of all sorts for *twenty-five* cents an acre per annum; and we will, therefore place the damage at one-half of the above amount—ten million dollars per annum.

Supposing that, as a consequence of this investigation, we are able to take measures which shall result in the increase, by so much as one per cent., of the efficiency of birds as an insect police, the effect would be a diminution of the above injury to the amount of sixty-six thousand

dollars per annum, equivalent to the addition of over one and one-half million dollars to the permanent value of our property; or, if, as is in fact a most moderate estimate, we should succeed in increasing the efficiency of birds five per cent., we should thereby add eight and one-fourth million dollars to the permanent wealth of the State, provided, as before, that birds do not eat unduly of beneficial species.

These figures will be at once rejected by most naturalists as absurdly low. The young robin of Prof. Treadwell (a bird whose fame has extended over both hemispheres) required not less than sixty earthworms a day to keep it alive. A pair of European jays have been found, Dr. Brewster informs us, to feed their brood half a million caterpillars in a season, and to eat a million of the eggs in a winter. I have myself taken one hundred and seventy-five larvæ of Bibio from the stomach of a single robin, and the intestine probably contained as many more.

Compared with these numbers, my two thousand four hundred insects a year for each bird seem certainly many times too few; and similar criticisms might very probably be made on other items of the estimate. I prefer, however, to put these matters with a moderation which will command general assent, especially as we see that the importance of the subject does not require exaggeration. Of course the individual farmer or gardener could, by intelligent and careful management, if he knew just what to do, increase the value of his own birds far beyond his individual share of the above-mentioned aggregate.

The subject has, also, a considerable scientific interest. Since the struggle for existence is chiefly a struggle for subsistence, a careful comparative account of the food of various competing species and genera, at different places and seasons and at all ages of the individual, such as has not heretofore been made for any class of animals, cannot fail to throw much light upon the details, causes and effects of this struggle. The flexibility of the food-habits of the widely ranging species, the direct effects of normal departures from the usual average of food elements upon the origin of variations and the general reactions of bir[illegible]

upon their organic environment, are examples of subjects upon which light should be thrown by this investigation.

That an element of such transcendent importance to all agricultural pursuits, and, through these, to the general welfare, ranking evidently among the larger forces of nature which affect powerfully and continuously the most essential interests of the country, should never have been made the subject of continuous, systematic and accurate study, seems, at first, a surprising phenomenon. It is a subject, however, presenting few attractions to the scientific student, requiring a great amount of time, a good knowledge of ornithology, a minute acquaintance with considerable parts of entomology and botany, and a good degree of skill with the microscope, while it profits the student but slightly relatively to the work done, by way of an increase of his knowledge. What little he learns is gained at every disadvantage. His material is in the worst possible condition for study; and the personal result of his labor is a continual discouragement to him. That whatever individual impulse should have been turned in this direction should have been exhausted long before definite or conclusive results were reached, was, therefore, inevitable. The student soon turned his attention to matters more attractive and more fruitful in knowledge and reputation. In short, this is emphatically one of those questions which, if studied exhaustively at all, must be studied chiefly in the public interest.

The primary purpose of this investigation is the determination of the exact relation of the different species of birds, and of the class in general, to agriculture and horticulture; it would be disgraceful to those in charge of this investigation if the opportunity were to be thrown away which it offers for an increase of that knowledge of the habits and relations of birds whose interest is strictly scientific rather than practical, and this has therefore been held in mind throughout as a legitimate secondary purpose. We need a full knowledge of the direct and indirect benefits and injuries attributable to each species—the ratio of benefit to injury, where both are apparent, the numbers, distribution and migrations of all, and, in fact, a full acquaintance with their entire natural history.

The direct injuries due to birds commonly take the form of depredations upon the fruits of the garden and orchard, and upon the grain in the fields. It is, of course, necessary to know the species chargeable with these, and the ratio which such injuries bear to the benefit likewise attributable to them. The good done by birds is almost wholly indirect, consisting chiefly in the destruction of insects which would become directly or indirectly injurious if allowed to live. Much of the apparent evil for which they are held responsible is also indirect; viz., the destruction of parasitic and predaceous insects which, if not destroyed, would help to diminish the numbers of injurious species. I wish, however, to call especial attention to the fact that *the regular and continuous destruction of parasitic and predaceous insects by birds is not necessarily an evil.* Paradoxical as this statement may seem, it is fully borne out by the following facts:

The most serious losses of the farmer and gardener due to insects are not consequent upon the ordinary and uniform depredations of those species whose numbers remain nearly constant, year after year, but upon excessive and extraordinary depredations of those whose numbers are subject to wide fluctuations. Vegetation has become so far adjusted to our crickets and ordinary grasshoppers, etc., that the foliage they eat can be spared without injury to the plant, and the damage done by them is commonly imperceptible.* It is far otherwise, however, with the vast hordes of the Rocky Mountain locust, of the Colorado potato-beetle, of the chinch-bug and of the army-worm, and many other species which occasionally swarm prodigiously and then almost disappear from view. The injurious species are chiefly the oscillating ones, and the dangerous species are those which show a tendency to oscillate. Anything which tends to limit the fluctuations of an oscillating species, or to prevent the oscillation of a stable species is, therefore, highly useful, while anything which tends to intensify an oscillation, or to convert a stable species into an oscillating one, is as highly pernicious.

* See Kirby and Spence's Introduction to Entomology, 4th ed., 1822, Vol. I, pp. 247-258.

Now a species is stable because the rate of its reproduction is uniform, because the checks upon its increase are substantially unvarying, and because these two forces balance each other. To set up any vibration in any one of these checks, will necessarily cause a corresponding vibration in the number of the species limited by it. More explicitly, to set up an oscillation in a predaceous or parasitic species must produce a reverse oscillation in the species parasitized or preyed upon. As the former increases, the latter must diminish, and *vice versa.* But either a marked decrease or a marked increase of a species will cause it to oscillate, unless made with extreme slowness—a slowness so extreme as to allow progressive adjustments of all kinds to keep pace with it.

Taking a predaceous beetle as an example, we see that a rapid decrease of its numbers, partly relieving the species which it preys upon from one of the usual checks upon its multiplication, will affect an increase in those species—will thus render the food of the predatory insect more abundant. This will, in turn, faciliate individual maintenance of the predatory insect and thus stimulate reproduction, initiating a forward movement, which, proceeding at a geometrical ratio, must continue until the predaceous species becomes too numerous for its food, or reaches other limitations; when destruction of the excess produced will send it back below the average line again. An oscillation will thus necessarily arise which must be reproduced in the food species connected with it.

On the other hand, if the predaceous species be suddenly increased in number by a diminished power or stringency in one of its accustomed checks, the process will simply be reversed, but the resulting oscillation will be the same. The predaceous species will increase geometrically until its food supply becomes insufficient for it, then by starvation and diminished reproduction it will be again reduced, and so on indefinitely. *Any* marked disturbance of a *fixed adjustment* between the rate of reproduction and the death rate, whether it result in increase or decrease, whether it affects a beneficial or an injurious species, is, therefore, in itself, an *immediate* evil; only to

be incurred where the ultimate good is a certain and liberal compensation.

Again, it is becoming evident that carnivorous insects and insectivorous birds all have their food-preferences. Probably no one species—certainly no one family—of birds or insects would quite take the place of another. Supposing, then, that some birds eat predaceous insects, in part, as well as phytophagous ones—eat the former, perhaps, in undue ratio—still, as the chances are practically infinite that the predaceous insects it eats would not, if allowed to live, eat precisely the same amount and kind of injurious insects as the bird itself, by destroying the bird we should merely liberate a second cause of numerous oscillations Those species neglected by the carnivorous insects would increase beyond their bounds, and those eaten by them would be unduly diminished. It follows from the foregoing reasoning that, as a general rule, *a bird should not be discredited for the regular and established habit of destroying predaceous or parasitic insects,* unless it can be shown that those insects would, if left to themselves, check the fluctuations of some injurious species, or afford a better safeguard against the possible fluctuations of others. It must also be shown that this prospective good will not be overbalanced by some greater evil. In short, the whole burden of proof is on the side of those who would disturb the fixed order of Nature.*

The most important question respecting the relations of birds to insects is, therefore, the determination of those species of birds which serve the most useful purpose as a *constant* check upon those insects which are either injurious or capable of becoming so if they appear in largely increased numbers. Fortunately, whatever oscillations or irregularities may arise, and whatever may be their cause, the general tendency of things is towards their correction. In course of time, if new disturbances do not continually unsettle even the newest arrangements, they will usually right themselves more or

* For a discussion of the general subject, see Herbert Spencer's Principles of Biology, Vol. 2, Pt. VI, Chap. II, p. 397; and the preceding paper, "On Some Interactions of Organisms." in this volume

less completely. The methods of this spontaneous restoration of the unsettled balance of natural forces, are, of course, worthy of the most careful study. It is only by working in harmony with them that we ourselves can help to readjust the disturbed order. A fuller treatment of this matter may best be postponed until the general discussion of results obtained by the investigation. Enough has been said to show that the subject, although complicated and difficult, will richly repay the study necessary to its mastery. A full and accurate knowledge of the mutual relations of the various forms of organic life of a region, both normal and abnormal, is certainly quite as essential to the general welfare as a knowledge of the chemistry and geology of its soils, the peculiarities of its meteorology, or any other part of the inorganic environment.

Concerning the special subject of this paper the knowledge we need is such that we shall be able to afford for every species a tolerably correct answer to the questions, What would be the main consequences if this species were exterminated? if it were reduced to half its present numbers? What if it were doubled in number? if it were quadrupled? When this is known, we shall evidently be able to act wisely and with the best results. That these questions are not unanswerable, I shall undertake to prove by answering them in substance, for several species, in this paper, and by demonstrating the sufficient accuracy of the answers.

Methods.

Three methods are possible in determining the food of birds. The birds may be fed in confinement, and the kinds of food apparently preferred and the amount eaten may be noted. This evidently shows only what the bird *will* eat when restrained of its liberty, of such food as may be placed before it, and furnishes few data which we can use with safety in making up an account of its food in freedom, when foraging for itself. The state of confinement is so abnormal for a bird that on this account, also, we can rarely reason from its habits in that state to its ordinary habits. This method is, therefore, available only

for the solution of a few separate questions. A far more useful method, and, in fact, the usual one, is that of watching birds while taking their natural food in the free state. Now and then a fact may be learned in this way which would escape detection in any other—such as the perforation of cocoons of Cecropia by the downy woodpecker reported by F. M. Webster*—but usually this method is of wholly secondary usefulness. The difficulty is very great of telling with certainty, in the great majority of cases, just what a bird is eating, even if one watches it with a glass. The notion of the food resulting must be distorted, as the species will be seen much more frequently and clearly in some of its haunts than in others. It is impossible by the use of this method, even to *guess* intelligently at the *ratios* of the different elements of the food—a matter of the first importance to an understanding of the subject. It yields very few facts for the time expended, and these, in nearly every instance, could have been learned in much less time, with far greater certainty, and in far greater detail by the following method. Finally, it affords no means of reviewing observations, but the impressions received from the hasty and imperfect glance of a moment must either be rejected wholly or must stand as verified observations.

By the third method, however, that of examining the contents of the stomachs after death, each bird usually affords a large number of objects which can be studied critically, and in detail, and can be indefinitely preserved for reference. These objects give a nearly or quite complete and impartial record of the food for some hours past—those elements taken in a thicket or a tree-top being as evident as those taken on open ground. They are usually identifiable by the skilled student. Even very minute fragments will tell as much as the out-of-door observer can learn under the most favorable circumstances. In the great majority of cases it is possible so far to fix the kinds of food as to bring every element clearly into one of the three classes, beneficial, injurious or neutral.

* In an unpublished paper read at the meeting of the Illinois State Nat. Hist. Soc., at Bloomington, Feb. 1880.

And here opportunity is afforded for careful and trustworthy estimates of the ratios each element bears to the other, so that the average significance of the food can be discovered. Practically, this is indispensable. Whatever method fails of this, while its results may be interesting, and may have a certain general value, can never afford a basis for anything better than indefinite opinion. It can never settle the case for or against the birds.

This method, while by far the best of the three, has its slight disadvantages. Some things eaten by birds leave no appreciable trace in the stomach. For example, it is difficult, by this method, to determine with certainty those birds which greatly injure grapes by breaking the skin of the fruit and sipping the juice. This difficulty applies only to liquid food. Other errors may arise from the shorter or longer periods for which different kinds of food will last in the stomach; but of this we have no proof. I have depended almost wholly on this third method of investigation, because it is evidently the most profitable and reliable, and because the method of cursory observation having been resorted to heretofore, most of the recorded facts are due to it. So far as one method could correct the deficiencies of the other, it was desirable that this more tedious and laborious but more fruitful one should be given greater prominence.

The stomachs of birds shot at all times of the year, and in all parts of the State, have been preserved in alcohol, each labeled with name, date and localilty. The contents of these stomachs were afterwards transferred, for permanent preservation, to separate vials, bearing copies of the original labels. They were then examined, bit by bit, with the microscope, with whatever powers were necessary to the fullest possible understanding of each fragment. It has been no uncommon thing to spend half a day over a single bird. Full notes of the materials found in each stomach were made on separate slips, and after this careful examination an estimate was made and recorded of the ratios of the different elements to the whole mass of the food of each individual. Objects which I was not able to identify have usually been sent to some more

experienced specialist, except where determination was evidently impossible.*

These memoranda were afterwards classified and the data arranged in tabular form, so as to give a complete recapitulation and summary of the food of each species for each month. The tables thus constructed have furnished the basis for the discussion of the food of the species; and a similar tabular summary of the food of the family has been used in a similar way. Thus every fact observed appears in the final conclusion, and receives, there, its due weight.

Family TURDIDÆ. The Thrushes.†

This family consists, in Illinois, of nine species of birds; the robin, the catbird, the brown thrush, the wood thrush, the hermit thrush, Swainson's thrush, the Alice thrush, the mocking-bird and Wilson's thrush or the Veery. The first four of these stay with us in this latitude during the summer; the others emigrate beyond our borders, except the mocking-bird, and that only reaches the southern third of the State in any considerable numbers. I have now carefully studied the food of three hundred and fifteen specimens of this family, shot in various parts of Illinois, and in all months from February to October.

Turdus migratorius, L. The Robin.

This bird, as familiar to every one as the domestic cat, is the most abundant of the thrushes, and plays so large a part in the economy of the farm and garden as to make the question of its food one of unusual importance. The species ranges from the Atlantic to the Pacific and from the Mexican plateau to the Arctic circle, at home in all the latitudes and longitudes of this vast and varied country. I cannot, of course, attempt to determine, at present, the food of the species throughout this immense area,

* For assistance of this sort, I am indebted above all others to Prof. C. V. Riley, Chief of the U. S. Entomological Commission at Washington, D. C. I have called upon him especially for the identification of larvæ, and my drafts have never been dishonored.

† The general reader is referred to the "recapitulations" and the discussions of "the economic relations" of each species for the most important facts of these papers.

but shall endeavor to show only what it eats under ordinary circumstances within the limits of Illinois. The species is not strictly migratory, but is reported as wintering, sometimes in considerable numbers, as far north as the White Mountains, in New Hampshire. It occurs but very rarely in winter in central or northern Illinois, as there is at that season not sufficient food to tempt it to brave our prairie winds. On the other hand, it is comparatively rare in southern Illinois in summer, but usually abundant there in autumn and winter, so that as far as this State is concerned, it is practically a migrant within our limits. In the latitude of Bloomington its advent depends on the forwardness of the season, but it usually appears not far from the first of March, and the last of the species are gone by October 15th or November 1st.

The nesting habit of this species is so varied that no special provision need be made by those wishing to encourage its multiplication. The lower branches of orchard trees are probably its favorite situation, but it selects the most various places and uses little art or caution in the concealment of its nest.

February.

The robin appeared at Bloomington, this year, in considerable numbers, about the middle of February, the spring being an unusually early and open one.

Eleven specimens were shot at Normal on the 27th and 28th, and their stomachs carefully searched for food. We first note that ninety-nine per cent. of the food of these birds was insects, the remaining one per cent. being spiders. About fourteen per cent. of the food of these early birds consisted of caterpillars, all of them eaten by three birds, while seventy-six per cent. taken by every bird, was the larva of a slow, torpid fly, abundant in early summer, closely related to the Tipulids or crane-flies (*Bibio albipennis*, Say). Prof. J. W. P. Jenks, now of Brown University, found this same larva to constitute about nine-tenths of the food of the robins examined by him in Massachusetts, in February and March, 1858—a

fact which indicates a remarkable fixity of food habits, unaffected by twenty years of time and a distance of a thousand miles. The caterpillars were partly cutworms, about one-third of them being recognized as the "speckled cutworm" (*Mamestra subjuncta,* G. & R.), a species supposed to be injurious to cabbages.* Coleoptera occurred in the stomachs of these birds only in small numbers, comprising about four per cent. of the food. Half of these were Carabidæ, eaten by six of the eleven birds, a fourth were scavenger beetles (*Aphodius inquinatus*) and a fourth were larvæ of Lampyridæ, including one of Chauliognathus. A few fragments of curculios were also found.

Grasshoppers were present in about the same quantity as beetles, but only two birds had eaten them. One had taken *Tragocephala infuscata* and another a Tettigidea.

The Hemiptera (one per cent.) were chiefly soldier-bugs (Pentatomidæ), eaten by five of the birds. The spiders had been taken by two birds, and one had eaten a small thousand-legs (Iulus).

The striking feature of the month is the great predominance of the larva of Bibio in the food, a fact which will seem of small or great importance according to our views of the habits of this larva. By Dr. Fitch, former state entomologist of New York, as quoted by Prof. Jenks,† it was believed to be especially injurious to grass lands, and the robin was therefore credited with an indispensable service to the farmer. Dr. Fitch gave no actual observations, however, and his opinion was apparently speculative. Mr. Walsh‡ and Prof. Riley have since reported that the larva feeds only on decaying vegetation and is therefore harmless, if not indeed useful. Prof. Riley has, in fact, reared it in rotten leaves where no living vegetation was accessible. Finding the robin feeding on it so excessively in spring, I took some specimens from among the roots of grass and weeds in a raspberry garden and others from the stomach of a robin, examined

* Prof. Riley, by whom my specimens were determined, says that he reared the larvæ on cabbage, which it ate voraciously.

† Journal of the Massachusetts Horticultural Society, Boston, March, 1859, p. 152.

‡ The Practical Entomologist, Vol. 2, No. 4, p. 45, January, 1867.

the contents of the intestine with a microscope, and mounted the material for permanent preservation. These larvæ were filled with vegetation, some of which was recognized as the leaves and rootlets of the grass-like weeds of the vicinity, while the remainder evidently consisted of the leaves of net-veined plants, probably trees, by which the ground was overshadowed. The frequency with which these tissues were found penetrated by fungi showed that this vegetation was in a decaying condition. I next looked through my notes of the contents of the stomachs of meadow-larks shot at the very time when the robins were stuffing themselves with this Bibio larva, and found that the meadow-larks had not eaten so much as one. As they search the ground more closely than the robin, relying almost as fully on insect food, this seemed good evidence that the larva occurs here chiefly in situations frequented by the robin and not by the meadow-lark—that is, in gardens, groves and the like. It was only in such situations that I was able to find it myself. There is, therefore, no present evidence that this larva is now injurious even in the slightest degree, and the robin is not entitled to any very positive credit for its destruction. There is some probability, however, that if the insect were allowed to increase indefinitely, it would become injurious to living vegetation; and if so, the high rate of its multiplication would make it a seriously destructive pest. The immense numbers annually destroyed by the robin may be inferred from the fact that I have counted as many as one hundred and seventy-five from the stomach of a single bird; and as fully half of the food of the robin for a month consists only of this insect, fifty larvæ a day for each robin, or one thousand five hundred for the month, will be a very moderate estimate.

About five per cent. of the food of February consisted of beneficial insects.

March.

Nine birds were shot on four different days of March, between the 9th and 31st, six of them in McLean county, and three at Galena. Four of these had eaten Bibio larvæ again, which amounted to thirty-seven per cent. of the

food of the month. Four birds are to be credited with the thirty per cent. of caterpillars destroyed. About two-thirds of these were cutworms, among which *Agrotis messoria** was recognized. A few were the larvæ of Arctiidæ, probably Callimorpha. Eighteen per cent. of the food eaten by seven of the birds, was made up of Coleoptera, two-thirds of which were scavenger beetles (*Aphodius fimetarius* and *A. inquinatus*). Carabidæ and their larvæ made but two per cent. of the food. Harpalus was the only genus distinguished. A few Histeridæ, a few wireworms (larval Elateridæ), a soldier-beetle (*Telephorus bilineatus*), and traces of long-snouted curculios† were the remaining beetles. Hemiptera were found in somewhat larger number and variety than in the preceding month. Among these were the raptatorial species, *Coriscus ferus,* and also *Phytocoris lineolaris, Cœnus delius* and *Euschistus servus.* The soldier-bugs (Pentatomidæ) made about two-thirds of the three per cent. of Hemiptera taken in this month. Grasshoppers were present in about the same amount as before, and the same species appeared in the food. A few spiders and thousand-legs and berries of sumach (*Rhus glabra*) complete the list. The large percentages of cutworms, Bibio larvæ and dung-beetles are thus seen to be the principal features of the food of these birds. Excluding the Bibionidæ, about thirty-seven per cent. of the food was composed of injurious insects and six per cent. of beneficial species.

April.

The robin is represented in my notes of this month by seventeen birds shot at Normal, Warsaw, Elizabeth and Hanover (JoDaviess county), Waukegan and Evanston, at various dates between the 2d and 27th. The high insect averages are maintained. Caterpillars are nearly as

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* All the cutworms but one mentioned in this paper were determined by Prof. Riley.

† I have used throughout this paper the somewhat artificial divisions of Longirostres and Brevirostres as applied to the Rhynchophora, because nearly all the especially injurious species belong to the former section. In fact, I have not hesitated to use an obsolete classification wherever the groups thus formed correspond better to the differences of food habit or of economic value than those made by the highest modern authorities.

abundant as before and make about a fourth of the food. Arctiidæ and Phalænidæ (measuring-worms) appear in some quantity, but of unrecognized species. The larvæ of Bibio fall to eight per cent. and do not again appear in the food during the year.

A strong upward jump in the ratio of Coleoptera, which rise in this month to forty-two per cent., is doubtless due to the greater activity of beetles during this season of their amours. The effect is clearly seen by running along the line of averages for Coleoptera from February to October, viz.: 4, 18, 42, 44, 15, 9, 7, 5, 3. The upward swell which commences in March and dies away in June, corresponds to the time when the procreative impulse overcomes the usual discretion of these insects, and draws them out more freely into the open air. It is in this month that the bird makes its principal attack on the predaceous beetles, which are represented by an average of seventeen per cent., eaten by eleven of the birds. Thirteen heads of *Harpalus herbivagus,* for example, were taken from the stomach of a single robin. Other species of Harpalus, *Brachylobus lithophilus, Anisodactylus baltimorensis, Geopinus incrassatus,* Pterostichus and Amara were observed. Scarabæidæ also occur in unusual abundance at this time (fifteen per cent.), as might be anticipated by one who recalls the numbers in which they are now seen flying in the air. May-beetles (Lachnosterna) make about half of these, and Aphodii the other half. A single bird had happened upon an interesting store of water-beetles (Hydrophilidæ) which included a specimen of *Hydrocharis obtusatus,* several of *Philhydrus cinctus,* and a number of Helophori unknown to me. Rhynchophora amount to about three per cent. of the food. Only Centrinus and *Graphorhinus vadosus* were recognized. Minor items were the traces noticed of Elateridæ, Lampyridæ and Chrysomelidæ.

Hemiptera stand at about the ordinary average (three per cent.), as usual chiefly Pentatomidæ. *Coriscus ferus,* some indeterminable Reduviid, *Podisus modestus* and *Hymenarcys nervosa* were the principal forms. The Orthoptera (five per cent.) call for no especial remarks, neither

do the Arachnida (one per cent.). One bird had eaten a predaceous thousand-legs (Geophilus), and two had eaten earthworms (five per cent.) The infrequent occurrence of the last in the stomachs of robins surprised me. It is probably due partly to the greater digestibility of these soft worms as compared with the chitinized skins of insect larvæ, and partly to the fact that the greater part of those taken by the robin are fed to the young. A few sumach berries eaten by the woodland robins shot in northern Illinois complete the dietary of the month.

The April food of the robin is, therefore, especially noticeable for the greatly diminishing number of Bibio larvæ and the excessive number of beetles eaten, especially of the Carabidæ and Scarabæidæ.

May.

Fourteen birds were studied for this month, all but two of them from various parts of northern Illinois. The record of May is substantially a duplicate of the April list, except in a few particulars. The Bibio larvæ are replaced by seven per cent. of adult crane-flies (Tipulidæ) and the Carabidæ drop to four per cent., the balance being almost exactly replaced by the scavenger beetles and leaf-chafers added. Chlænius and *Agonoderus partiarius* are among the captures of these birds. Lachnosterna rises to its highest point in May, and is represented by seventeen per cent. of the food. Wireworms (Elateridæ) are likewise unusually abundant, for some unexplained reason, amounting to eight per cent. A single robin had eaten a single potato beetle (*Chrysomela 10-lineata*), and one had taken a specimen of *Prometopia 6-maculata*. *Cœnus delius* appears among the Pentatomidæ and Polydesmus among the thousand-legs; and sumach berries again occur.

June.

With June the robin revolutionizes his commissariat. The insect ratios, which have averaged ninety-five per cent. during the preceding months, now drop to forty-two, and remain at or below this point for the rest of the year; and this lack is compensated by the appearance of

fifty-five per cent. of cherries and raspberries. The loss falls chiefly upon the Diptera and Coleoptera, the former dropping from eleven per cent. to less than one, and the latter from forty-four per cent. to fifteen. Among the families of Coleoptera we see from the table that it is the Scarabæidæ which benefit chiefly by this diversion of the robin's activities; for, while the other families remain about as before, this family drops from twenty-two per cent. in the preceding month to one in this.

Taking up the details of the food of the thirteen June robins, ranging from the 10th to the 29th, all shot at Normal, we first notice the larger percentage of ants. These have hitherto occurred in but trifling numbers—(three per cent. in the preceding month)—but are now more than twice as common in the food. This fact is doubtless due to the same cause as the still greater relative abundance of the ants in June in the food of the bluebird—to the abundance of the winged perfect forms of some species at this time. Caterpillars stand at seventeen per cent., seven per cent. being cutworms. Carabidæ form six per cent. of the food. Among the adults were *Callida punctata, Cratacanthus dubius,* Agonoderus and Anisodactylus. Wireworms were again numerous, four per cent. being eaten by seven of the birds. Forty-seven per cent. of the food of these birds was cherries and eight per cent. raspberries.

July.

The fourteen July birds were evidently reveling in the fruit garden, raspberries, blackberries, and currants forming seventy-nine per cent. of the food.*

On the other hand, but twenty per cent. of the food was insects and one per cent. was spiders. The caterpillars furnish only four parts of the food, and beetles but nine parts, of which two-thirds were Carabidæ. Evarthrus, Pterostichus and Amara were noticed among these. Scarabæidæ, Elateridæ, and Rhynchophora each one per cent., a mere trace of Hemiptera, four per cent. of Orthoptera (chiefly crickets), eaten by two of the birds, and

* I have not ordinarily attempted to distinguish raspberries from blackberries in the stomachs of birds, but have set down either one or the other, according to the advancement of the season.

one per cent. each of Arachnida and Myriapoda are the remaining trivial details.

August.

This month is represented by twenty birds, all shot at Normal,* at repeated intervals from the fourth to the thirtieth. With the disappearance of blackberries, the food of this bird returns substantially to the status of June. Insects increase again to forty-three per cent. and fruits fall to fifty-six. Ants remain at the usual point of insignificance, caterpillars rise again to seventeen per cent., about two-thirds of them Noctuidæ. Coleoptera figure at seven per cent., only two per cent. being Carabidæ, Rhynchophora rise to four per cent., eaten by nine of the birds; and, except a stray Nepa picked up by one robin, Hemiptera appear in trifling quantity. Crickets and grasshoppers are more abundant, amounting to ten per cent. of the food.

The cherries made forty-four parts of the food of the month, eaten by fourteen of the birds, *but two-thirds of these cherries were wild.* Tame grapes make three per cent. of the food, berries of the mountain-ash about four per cent., and blackberries from the woods not far from five per cent.

September.

Twelve birds, all but one shot at Normal September 25th, and that one at Aurora on the 13th, show no more remarkable peculiarity than the substitution of ants for most of the caterpillars, the former composing now fifteen per cent. of the food, and the latter but five. The ants were largely winged, but of different species from those taken most freely in June.† The Carabidæ of this month were chiefly larvæ. Among the Hemiptera (three per cent.) were found *Mormidea lugens* and *Cœnus*

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* The general cessation of taxidermist's field work in midsummer has prevented the supply of any material for this month and the preceding, except that obtained by ourselves in McLean county.

† Examining the tables of food of the bluebird, brown thrush and robin, I find throughout a curious inverse relation between the ratios of ants and caterpillars, the latter falling away in June to about the same degree that ants increase during the time of their most conspicuous activity. I cannot even guess why ants should thus replace caterpillars in the food.

delius. No trace of spiders or myriapods was found, and only two per cent. of grasshoppers. The fruits stand at seventy per cent., fifty-two per cent. being grapes and the remainder berries of the mountain-ash and moonseed (Menispermum).

October and December.

The robin commences to withdraw to the south in October, and his operations in central Illinois have little interest during this month. At Normal the species became rare earlier than usual this year, and but three specimens were secured. These were feeding largely on wild grapes (fifty-three per cent.) and ants (thirty-five per cent.). Six per cent. of the food was caterpillars and two per cent. wireworms (Elateridæ). I have seen the bird eating apples in all the autumn months, but have never found the remains of this fruit in the stomach, and doubt if any special harm is done in this way.

A single bird shot at Cairo in December, piping loudly from a tree-top for company, the only one of the entire family seen during a week's winter shooting in southern Illinois, had evidently been feeding on the berries of the mistletoe. By the inhabitants of that region, troops of robins which commonly winter there were said to have gone south in November, a fact attributed by them to the failure of the wild grapes in the woods that year.

Recapitulation.

The food of the robin, as indicated by the stomachs of one hundred and fourteen specimens, consists almost entirely of insects from February to May inclusive, but from that time forward these make but little over a third of its food, the remainder (sixty-four per cent.) being composed of fruits, tame and wild, in varying proportions, according to the local situation and surroundings. Insects make almost precisely two-thirds of the food of the year, taken as a whole.

In early spring the bird depends chiefly for food upon the larvæ of a single species of fly (*Bibio albipennis*, Say), which it picks from among the leaves and roots of grass and weeds in gardens, and similar situations. In

February this made three-fourths of the food of eleven specimens, and in March more than a third of the food of nine. While this larva is not at present injurious, but feeds ordinarily on decaying vegetation, it might possibly do injury to meadows and pastures if allowed to multiply without restraint.

But few ants are eaten by this bird until late in the fall, when the swarming of the sexual forms of some of the species seems to attract its appetite, in the relative dearth of other insects.

Caterpillars make up, in March, April and May, fully a fourth of its food, about half of these being cutworms and other similar forms. Later, these are largely given up for fruit, and in the latter half of the season make only about one-tenth of the food. The average of caterpillars for the year is seventeen per cent.

Beetles, commencing at four per cent. in February, when but few specimens have yet been aroused from their cold winter's sleep, rise to forty-four per cent. in April and May, when their procreative energies are most active and urge them out into the air in swarms. With the appearance of the small fruits, beetles, also, are neglected by the robin, and the average for the last four months of the season falls away to six per cent., eighteen being that for the year.

This discrimination affects chiefly the scavenger beetles and the "June beetles," the other families maintaining about their original numbers throughout, with only an upward wave in April. The predaceous beetles average six per cent. of the food of the year, the leaf-chafers three per cent., the wireworms two per cent., and the snout-beetles one per cent.

The robin's depredations upon the true bugs (Hemiptera) are but trivial, amounting only to three per cent. of the food, but nearly all of these belong to species regarded more or less positively as beneficial.

The ratio of grasshoppers and crickets (four per cent.) seems trivial at first sight. We note, however, that these were eaten by twenty-six of the birds, and that, consequently, at least twenty-six of the insects must have been destroyed. Remembering that these figures are based

upon a single day's food, or even less, for each bird, we see that these robins were eating at an average rate of at least twenty-six grasshoppers or crickets a day, for seven months, giving us a minimum total of 5,500 Orthoptera for the year.

Only one per cent. of the food was spiders. Thousand-legs were eaten by eight of the birds, and by these in merely trivial quantity.

Coming now to the fruits, we find that tame cherries, blackberries, raspberries, currants and grapes, excluding wild fruit of all descriptions, make about one-fourth of the food of the species for the year, the wild fruits making another tenth. In the absence of the latter, the robins would doubtless attack the garden fruits more vigorously.*

Concerning these general statements, the all-important question is, of course, the sufficiency of their basis.

Granting that the observations have been exactly made and correctly generalized, how far may the conclusions reached be expected to hold good in the future? These conclusions actually rest upon the food of a hundred and fourteen birds for probably about half a day each. Can we safely reason from these to the food of the thousands and hundreds of thousands of robins of the State, day after day, the whole season through?

In a paper published last winter in the Transactions of the Illinois Horticultural Society, I made the following reply to substantially the same question:

"If the same species will eat substantially the same food, year after year, in the same situation, then, of course, a good deal may properly be inferred from comparatively few data; but if the food varies widely, either arbitrarily or under slight changes of condition, then we can infer but little. Upon this fundamental question I have two suggestions to make.

"First, if several species allied in structure, occupying the same territory at the same time, living side by

* No man should needlessly sacrifice a wild cherry-tree or a fruiting vine or shrub of any kind. Ordinary common sense would teach the preservation of as much of the worthless natural food of frugivorous birds ~~are~~ possible, as a diversion from the cultivated fruits of the orchard and garden.

side, with the same sources of food supply open to them, are found, on the examination of a limited number of stomachs, to present several characteristic differences of food, so that the investigator can point out definite peculiarities of the food of each species, and finds these peculiarities reasonably constant, year after year, then we may say unquestionably, without going farther, that there is a fixity of food-habits in this group of birds which will allow us to reason from the data observed.

"Second, if there are any other habits of the species in which there does not seem to be any greater reason for invariableness than in those relating to the food, which are nevertheless found to be substantially unvarying, then we may, with considerable force, argue the probability of a like unvarying character in the habits of alimentation.

"Respecting the first of these tests, you will see, when I sum up the food of the family now under consideration and bring the data respecting the various species into comparison with each other, that I have made out certain very well-marked specific differences of food, even among those eating at the same table; that the different species of this group, while agreeing in many particulars of food as they do in structure, present also certain peculiarities, so marked that I can usually determine the species by the contents of three or four stomachs.

"For the second test we may properly use the nesting habit. There seems to be no more cogent reason why one species should select from the same storehouse different materials for its nest from those used by another closely allied species of nearly the same size and similar general habits, and building in the same locality, than why each should use a similar fixed discrimination in selecting its food. Yet no expert, scarcely a schoolboy even, will hesitate a moment between the nest of a robin and that of a catbird; and the descriptions of the two given in the books are so different as to enable any novice to distinguish between them at a glance. In fact, a friend mentions, as I write, two birds whose nests are much more easily distinguished than the birds themselves."

I have now to add what we may regard as a decisive crucial test of the conclusion implied above. In the paper quoted from, I gave the details and a summary of the food of forty-one robins in a table similar to those presented in this paper, and a comparison of the averages of that table with those of the table on pages 112, 113, 114, 115, may be easily made. While any serious differences in the averages of these two tables would not necessarily condemn the later one, but, at the worst, would leave its sufficiency in doubt, a substantial agreement of the two would be conclusive proof of the correctness of both. It is incredible that the averages of a hundred and fourteen specimens should agree essentially with those of forty-one, unless both were framed upon identical principles and were sufficiently true to the facts for all practical purposes. I will, therefore, place the principal averages of these tables side by side, premising that the later table not only includes nearly three times as many specimens as the earlier, but covers two months' more time.

The figures for the first and second tables, taken alternately, are as follows: Insects, seventy per cent, and sixty-five per cent.; caterpillars, eighteen per cent. and seventeen per cent.; Diptera, eighteen per cent. and seventeen per cent.; Coleoptera, nineteen per cent. and eighteen per cent.; Carabidæ, seven per cent. and five per cent.; Scarabæidæ, four per cent. and seven per cent.; Lachnosterna, two per cent. and three per cent.; Elateridæ, three per cent. and two per cent.; Rhynchophora, three per cent. and two per cent.; Chrysomelidæ, one per cent. and a trace; Hemiptera, four per cent. and three per cent.; Orthoptera, eight per cent. and four per cent.; Arachnida, a trace and one per cent.; Myriapoda, two per cent. and a trace; garden fruits, twenty-eight per cent. and twenty-nine per cent.

As I did not discriminate, in the former table, between tame and wild edible fruits, I have included the latter in both, and excluded the inedible fruits. I believe that the agreement in these figures, taking into account the earlier and later months covered by the second table, is quite remarkable, and can be explained only on the supposition that the fuller table presents a reasonably accurate sum-

mary of the food of the robin as a species in at least the northern half of the State, and under the ordinary conditions of the last five or six years. Of course, I had no idea how these averages were coming out until my notes were finished and the ratios were calculated for the whole.

Economic Relations.

We come now to the intricate, delicate and difficult question of the economic relations of this species—a question rendered less important by the general considerations urged elsewhere, but, nevertheless, deserving careful attention. While it is true that every insectivorous bird must be respected, whatever its other habits, at least until we clearly understand its function in the general order and are certain that its removal will do no harm which we cannot remedy or endure better than we can support its injuries, yet an idea of the relative importance of edible fruits and insects of both the beneficial and injurious classes in the diet of the bird is necessary as a step to this clear and complete understanding of the matter.

Glancing at the bottom of the table of the food of the species on page 115, the reader will see three lines of figures running across the page, showing for each month the percentages of beneficial, injurious and neutral species of insects and fruits eaten by these birds. The figures at the right give similar percentages for all the birds for the entire year. Following the upper line, we note the small percentages of injury done in the early spring, the marked increase of injury in April, due to the excessive destruction of predaceous beetles, and the heavy percentages of the fruiting months. The general average of beneficial elements destroyed for the year is thirty-six per cent. On the second line we notice an inverse variation. Commencing with a ratio of ninety-four per cent. of injurious elements eaten in February (if we include the larva of Bibio in these), the record runs down to seven per cent. in September, the general average for the year being forty-three per cent.

This comparison, however, is merely a quantitative one. Injurious or beneficial elements are balanced against each

other according to their bulk and not their quality. A quart of caterpillars counts as the equivalent of a quart of blackberries, and, on the other hand, as the equivalent, also, of a quart of predaceous beetles. It is evident, therefore, that we cannot get at any close estimate of the economic values of this species in this indiscriminate way.

A nearer approximation to the truth may be made by critically comparing the general averages for the year found in the vertical column at the right of the table. Here we have the following totals of injurious and beneficial species: Of the first, caterpillars, seventeen parts (including eight parts cutworms); Bibio larvæ, fifteen parts; leaf-chafers, three parts; wireworms, two parts; snout-beetles, two parts; crickets and grasshoppers, four parts. Of the second predaceous beetles, six parts; predaceous bugs, three parts; garden fruits, twenty-four parts. Now, the opinions of entomologists would probably be found to differ somewhat widely on the question of the relative values of these various elements, and each must form his own opinion from the data given.* My own judgment is that, taking into consideration only the immediate present effect of the robin upon the fruits and insects of the State, ignoring for the moment the important secondary disturbances likely to arise if the number of the species were greatly lessened, and balancing these elements carefully against each other (applying to them, in fact, the operation of cancellation in arithmetic), we can reduce the question finally to about this form: Will the destruction of seventeen quarts of average caterpillars, including at least eight quarts of cutworms, pay for twenty-four quarts of cherries, blackberries, currants and grapes?

To this question I, for my own part, can only reply that I do not believe that the horticulturalist can sell his small fruits anywhere in the ordinary markets of the world at so high a price as to the robin, provided that he uses

* Concerning the value of predaceous beetles, the reader is especially requested to examine the papers on that subject in the present bulletin. It is probable that their services have been greatly overestimated.

proper diligence that the little huckster doesn't overreach him in the bargain. In other words, while the bird is far too valuable to exterminate, at least until we are sure we can replace him by some cheaper assistant, yet he is not so precious that we need hesitate to protect our fruits from outrageous injury. Indeed, it seems likely that the ordinary destruction of robins by gardeners does not more than compensate for the destruction of birds of prey in the interests of the poultry yard—removing that excess of robins which, in the more natural order, would fall victims to the hawks and owls.

TABLE OF THE FOOD OF THE ROBIN. (*Turdus migratorius* L.)

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL	Ratio of each element to whole of food
Number of specimens.......	...	11	9	17	14	13	14	20	12	3	...	1	114	
KINDS OF FOOD.	Number of specimens, and ratios in which each element of food was found.													
I. MOLLUSKS...............	...	...	...	1 .01	1 †	...	...	...	...	...	...	...	2	....
II. INSECTS	...	11 .99	9 .97	17 .91	14 .94	13 .42	13 .20	18 .43	9 .30	3 .44	...	...	107	.65
1. *Hymenoptera*.............	...	...	1 †	5 .02	7 .03	6 .07	3 .01	10 .03	7 .15	2 .35	...	...	41	.04
Apidæ....................	...	...	...	1 †	...	...	1 †	...	...	...	...	...	2	....
Formicidæ	...	...	...	4 .02	7 .03	6 .07	3 .01	7 .02	7 .15	2 .35	...	...	36	.04
Ichneumonidæ	...	...	...	...	...	...	...	1 †	...	...	...	...	1	....
Chalcididæ..............	...	...	1 †	...	...	...	...	...	...	...	...	...	1	....
2. *Lepidoptera* (larvæ)......	...	3 .14	4 .30	12 .24	11 .23	8 .17	3 .04	11 .17	2 .05	2 .06	...	...	56	.17
Arctiidæ..................	...	...	1 .01	3 .02	...	...	...	...	...	...	...	...	4	....
Noctuidæ	...	1 .05	3 .19	1 .04	6 .15	4 .07	...	7 .12	1 .01	...	...	...	23	.08
Phalænidæ	...	...	...	1 .05	...	...	...	...	...	...	...	...	1	....
3. *Diptera*..................	...	11 .76	4 .38	6 .12	4 .11	1 †	1 .01	1 †	...	...	...	...	28	.17
Tipulidæ..................	...	...	...	...	2 .07	...	...	...	...	...	...	...	2	.01
Bibionidæ	...	11 .76	4 .37	3 .08	...	...	...	...	...	...	...	...	18	.15

TABLE OF THE FOOD OF THE ROBIN. (*Turdus migratorius*, L.)—Continued.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL	Ratio of each element to whole of food.
Number of specimens......	...	11	9	17	14	13	14	20	12	3	...	1	114	
KINDS OF FOOD.	Number of specimens, and ratio in which each element of food was found.													
4. *Coleoptera*.	...	8 .04	7 .18	16 .42	11 .44	11 .15	8 .09	14 .07	3 .05	3 .03	...	...	81	.18
Carabidæ	...	6 .02	5 .02	11 .17	6 .04	6 .06	3 .06	7 .02	2 .03	1 .01	...	...	47	.05
Harpalidæ	...	4 .01	4 .02	11 .16	6 .04	5 .01	2 .06	5 .02	2 .03	1 .01	...	...	40	.05
Larvæ	...	...	1 .01	...	...	1 †	2 .01	...	1 .02	...	...	...	5	....
Dytiscidæ	...	...	...	...	...	...	...	1 †	...	...	...	...	1	....
Hydrophilidæ	...	...	...	1 .01	...	...	...	...	...	...	...	...	1	....
Staphylinidæ	...	...	...	...	1 .01	...	...	...	...	...	...	...	1	....
Histeridæ	...	...	1 .01	...	8 .05	1 †	...	1 †	...	...	...	...	11	.01
Nitidulidæ	...	...	...	...	...	...	...	1 †	1 †	...	...	...	2	....
Scarabæidæ	...	3 .01	4 .12	13 .15	12 .22	4 .01	3 .01	1 .01	...	...	...	...	40	.07
Lachnosterna	...	...	...	2 .07	6 .17	1 †	1 †	...	...	...	...	...	10	.03
Elateridæ	...	...	2 .01	2 †	4 .08	7 .04	2 .01	1 †	1 †	1 .02	...	...	20	.02
Lampyridæ	...	2 .01	1 .01	1 †	...	1 .02	...	...	...	...	...	...	5	....
Rhynchophora	...	2 †	2 .01	5 .03	7 .02	4 .01	1 .01	9 .04	...	...	...	...	30	.02
Brevirostres	...	...	...	3 .02	4 .01	...	...	...	...	...	...	...	7	....
Longirostres	...	1 †	2 .01	3 .01	4 .01	...	...	2 .02	...	...	...	...	12	....
Chrysomelidæ	...	...	...	1 †	2 .01	2 .01	...	1 †	...	1 †	...	...	7	....
Doryphora	...	...	...	...	1 .01	...	...	...	...	...	...	...	1	....
5. *Hemiptera*	...	5 .01	3 .03	5 .03	6 .05	3 .01	2 †	6 .06	5 .03	...	...	...	[illegible]	.03
Nepa	...	...	...	...	...	...	...	1 .05	...	...	...	...	1	....
Coriscus	...	...	1 †	1 †	1 †	...	...	1 †	...	...	...	...	4	....
Reduviidæ	...	...	...	1 †	1 †	1 †	1 †	2 †	....	...	...	...	6	....
Phytocoreidæ	...	...	1 †	...	...	...	...	1 †	...	...	...	...	2	....

TABLE OF THE FOOD OF THE ROBIN. (*Turdus migratorius*, L.)—Continued.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL	Ratio of each element to whole of food.
Number of specimens	...	11	9	17	14	13	14	20	12	3	...	1	114	
KINDS OF FOOD.	Number of specimens, and ratio in which each element of food was found.													
Lygæidæ (Blissus)	...	...	...	...	...	...	...	...	1 †	...	...	...	1	....
Coreidæ	...	1 †	1 †	...	...	...	...	...	...	...	...	...	2	....
Pentatomidæ	...	5 .01	3 .02	5 .03	4 .04	1 †	1 †	3 †	4 .02	...	...	...	26	.02
6. *Orthoptera*	...	2 .04	2 .05	6 .05	5 .04	1 .01	2 .04	6 .10	2 .02	...	...	...	26	.04
Gryllidæ	...	...	...	1 .01	...	...	1 .03	3 .06	...	...	...	...	5	.01
Acrididæ	...	2 .04	2 .05	3 .03	5 .04	1 .01	2 .01	3 .04	2 .02	...	...	...	20	.03
III. ARACHNIDA	...	2 .01	1 .01	3 .01	1 †	...	4 .01	3 .01	...	...	...	...	14	.01
IV. MYRIAPODA	...	1 †	3 .01	3 .01	1 .02	...	...	...	...	...	...	...	8	....
Geophilus	...	...	1 †	1 .01	...	...	...	...	...	...	...	...	2	....
Polydesmus	...	...	...	...	1 †	...	...	...	...	...	...	...	1	....
Iulidæ	...	1 †	2 .01	2 †	1 .01	...	...	...	...	...	...	...	6	....
V. EARTHWORMS (*Lumbricus*)	...	...	...	2 .05	...	...	...	...	...	...	...	...	2	....
VI. FRUITS AND SEEDS	...	1 †	2 .01	1 .01	3 .04	13 .58	14 .79	17 .56	11 .70	3 .56	...	1 100	65	.34
Blackberries	...	...	...	...	...	...	12 .56	...	...	...	...	...	12	.07
Raspberries	...	...	...	...	...	3 .08	1 .05	...	...	...	...	...	4	.02
Cherries	...	...	...	...	...	10 .47	...	[a]14 .44	...	...	...	...	24	.11
Currants	...	...	...	...	...	...	6 .17	...	...	...	...	...	6	.02
Grapes	...	...	...	...	...	...	...	1 .03	7 .52	[b]2 .53	...	...	10	.07
Mistletoe (Phorodendron)	...	...	...	...	...	...	...	...	...	...	...	1 100	1	....
Mountain-ash	...	...	...	...	...	...	...	1 .04	1 .08	...	...	...	2	.01
Sumach (Rhus)	...	...	2 .01	1 .01	2 .04	...	...	...	...	...	...	...	5	.01
Hackberry (Celtis)	...	...	...	...	...	...	...	1 .05	...	...	...	...	1	....

[a] 28 per cent. wild. [b] All wild.

TABLE OF THE FOOD OF THE ROBIN. (*Turdus migratorius*, L.)—Concluded.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL	Ratio of each element to whole of food.
Number of specimens	...	11	9	17	14	13	14	20	12	3	...	1	114	
KINDS OF FOOD.	Number of specimens, and ratio in which each element of food was found.													
Moonseed (Menispermum)	...	...	...	...	...	...	...	...	2 .04	...	...	...	2	....
Polygonum	...	...	1 †	...	...	...	...	...	...	...	...	...	1	....
Grass	...	1 †	...	...	1 †	1 .02	...	...	...	...	...	...	3	....
Corn	...	...	...	...	...	1 .01	...	...	...	...	...	...	1	....
	Percentages for each month													Ratios.
Beneficial species	...	05	06	21	09	°64	°85	°50	°57	...	...	...	...	36
Injurious species	...	*94	*74	*47	55	24	10	31	07	...	...	...	...	43
Neutral species	...	01	20	‡32	‡36	‡12	‡05	‡19	‡36	...	...	...	...	21

*Includes Bibio. ‡Includes ants. ° Includes fruits.

[NOTE —In the foregoing tables, the integers indicate the number of birds found to eat the element against which they are placed, and the decimals express the ratio of this element to the whole food of the month. October and December were omitted in computing the general averages for the year, on account of the small number of birds for those months.]

MIMUS CAROLINENSIS, L. THE CATBIRD.

This bird, scarcely less abundant than the robin, arrives later and makes a shorter stay, coming late in April or early in May, and disappearing from this latitude usually in September. It also occupies a larger territory in the State in midsummer than the robin, being not at all rare in extreme southern Illinois in July and August. I do not know that it ever winters northward. Its habits and favorite haunts are so similar to those of the robin that one might not unreasonably anticipate that, respecting their food, both could be considered as one species; but we shall see proof that there are specific food characteristics to separate them.

How indefinite and uncertain is the present knowledge of the food of this especially notorious species, may be seen by comparing my notes with the statement made in the recent and elaborate work of Baird, Brewer and Ridgway.

"The food of the catbird is almost exclusively the larvæ of the larger insects. For these it searches both among the bushes and the fallen leaves, as well as the furrows of newly-plowed fields and cultivated gardens. The benefit it thus confers upon the farmer and upon the horticulturist is very great, and can hardly be overestimated."

My observations of this bird cover the five months from May to September, inclusive.

May.

The specimens of this month range from the 1st to the 31st, and from Warsaw and Normal, in central Illinois, to Savanna, McHenry and Waukegan in the northern part of the State. Five of the birds of the month were taken in northern Illinois and seventeen in the central part of the State. All of these birds had eaten insects, which amounted to eighty-three per cent. of the food, the remainder consisting of spiders, three per cent.; thousand-legs (Myriapoda), seven per cent.; and seven per cent. of the dry berries of the sumach (*Rhus glabra*). Among the insects were about equal ratios of ants, crane-flies and beetles, the first composing eighteen per cent. of the food, the second nineteen and the third twenty-three. Caterpillars formed twelve per cent. of the food, and about one-sixth of these were distinctly recognizable as cutworms (Noctuidæ). More than one-third of the beetles were Carabidæ including specimens of Platynus and *Harpalus pennsylvanicus.* Only one per cent. of the food consisted of Scarabæidæ, and five per cent of snout-beetles (Rhynchophora). Nearly all of the latter belonged to the section Brevirostres, in which are found few of the injurious species of the group. Those recognized were *Epicærus imbricatus* and *Ithycerus noveboracensis.* Among the one per cent. of plant-beetle (Chrysomelidæ) only *Gastrophysa polygoni* was specifically de-

terminable. Minor items among the Coleoptera are the water-beetles, including *Colymbetes biguttatus* and an undetermined species of Hydrobius. The Hemiptera amounted to only one per cent. of the food, and all of these were Pentatomidæ. The Orthoptera, including a few specimens of the white cricket (Œcanthus) and of the common spring grasshoppers, amounted in all to four per cent. of the food. A single specimen of the young of the walking-stick (*Diapheromera femorata*) had been eaten by one of the birds. Spiders amounted to three per cent. of the food. The Myriapoda included several specimens of Lithobius and three species of Polydesmus, viz.: *P. serratus, P. virginiensis* and *P. canadensis.*

It will be seen at once that the striking feature of the food of this bird in May, as compared with that of the robin, is the abundance of ants and crane-flies, a characteristic which we shall find persistent until the opening of the fruit season revolutionizes the food of both species.

June.

The food of June undergoes so complete a change when the small fruits begin to ripen that the record may best be given in two divisions, the first of which agrees closely with that of May, while the second approaches more nearly to that of July. In the first part of the month ants were eaten by the nineteen birds examined in about the same ratio as in May. Crane-flies appear in the food only in the early days of the month. Among the Coleoptera the principal peculiarity is the greater importance of the May-beetles (Lachnosterna). A few strawberries and cherries were eaten by this bird previous to the fifteenth of the month, but these fruits were not taken in sufficient amount materially to influence the averages. After the seventeenth, however, only one per cent. of the food consisted of ants, and only about three per cent. of caterpillars. The May-beetles disappear almost entirely, and the other insect elements are reduced to equal insignificance, while the same fruits constitute by far the larger part of the food. These include currants and cherries in about equal parts, and about twice as many raspberries as of both the others taken together. Treating the food of the

month as a whole, we find that forty-nine per cent. of it consists of insects, three per cent. of spiders and three per cent. of thousand-legs, while forty-five per cent. consists of fruits, twenty-one per cent. being raspberries, twelve per cent. cherries, three per cent. strawberries and eight per cent. currants. The ants of the month amounted to but eleven per cent. and the craneflies to seven per cent. The Lepidoptera stand at ten per cent. and the Coleoptera at seventeen—nearly one-third of the latter being Carabidæ. The Hemiptera made about one per cent. of the food and the Orthoptera two per cent. A single bird-louse (Mallophaga) was found in the stomach of one of these birds.

July.

The record of this month rests upon eleven specimens, all from central Illinois, taken from the first to the twenty-third of the month. These indicate most clearly an eminent preference of the species for the small fruits, which composed three-fourth of their food, sixty-four per cent. being blackberries alone. Spiders and myriapods, are found in about the same ratio as in June. The latter are all Iulidæ, a part of them, at least, belonging to the genus Iulus. The only Orthoptera noted were specimens of the large black cricket of the fields (*Gryllus abbreviatus*), eaten by a single bird. The Hemiptera almost disappear, a single Thrips being the only representative of the order. The Coleoptera amounted only to nine per cent. of the food, and more than two-thirds of these were predaceous beetles, eaten by eight birds; among these were noted *Cicindela lecontei*, Pterostichus, Evarthrus, *Cratacanthus dubius, Anisodactylus baltimorensis* and Harpalus. Only a single bird had taken caterpillars, which constituted three per cent. of the food of the month. No trace of Diptera was found in the stomachs of these birds, and only four had eaten ants, which made two per cent. of the total food. Insects proper thus amounted to eighteen per cent. of the whole.

It is clear, from the foregoing, that the catbird in midsummer eats only such insects as come in its way while regaling itself on the smaller fruits.

August.

Twelve birds were obtained in this month, the first on the 7th and the last on the 30th, all from McLean and adjoining counties. Three of these were young, but as no difference of food was noticed corresponding to age, these are not treated separately.

The food record of August resembles that of June, owing, doubtless, to the diminution of the smaller garden fruits at this time and to the fact that the wild fruits have not yet generally come into bearing. The insect percentages are, therefore, much larger than in July, and it is instructive to notice that this increase is first apparent and most evident in the ratios of ants—an indication of the positive preference of the catbird for this food. Nearly one-half of the forty-six per cent. of insects eaten in this month were ants. A bee, a gall-fly and an ichneumon were noticed among the other Hymenoptera. Forty per cent. of the food was caterpillars, a considerable proportion of which were cutworms. Only six per cent. of the food was Coleoptera, and the only predaceous beetle taken by these birds was one specimen of *Cratacanthus dubius.* Three per cent. of the food was scavenger-beetles, including Geotrupes and *Bolbocerus farctus.* It is in this month that the Meloidæ appear abundantly on goldenrods and other Compositæ, but only a single Epicauta was found in the food of one of these birds. The few plant-beetles noticed included a single *Diabrotica vittata.* Seven per cent. of Hemiptera were eaten; largely chinch-bugs, taken by one of the birds. This fearful pest of the grain-fields was sufficiently abundant in the vicinity of Normal this year sensibly to injure the crops of grain. Nearly all the species of birds examined were found to eat them to some extent, but in quantities so trifling as probably to have little or no effect upon their multiplicaion. It is evident, however, that the birds have no especial prejudice against them. The remainder of the Hemiptera were the ordinary "soldier-bugs", belonging to the genus Euschistus.

Orthoptera appear in somewhat larger ratio, amounting to seven per cent. of the food, an indication, doubt-

less, of the commencement of the autumnal multiplication of this order which will be found reflected to a very notable degree in the food of the bluebird further on. Only traces of spiders and thousand-legs were discovered. Fifty-four parts of fruit were eaten, sixteen of which were wild. Nearly all of the garden fruits were blackberries—cherries constituting but three per cent. of the food for the month.

September.

The catbird leaves our latitude in September, and only six specimens were secured—all of them on or before the 17th, in the vicinity of Normal and Bloomington. The chief peculiarity of the food of the month is the substitution of cherries and wild fruits for blackberries. Seventy-six per cent. of the food at this time consisted of fruits, all wild but the grapes, which amounted to fourteen per cent. Elderberries, wild cherries and the fruit of the Virginia creeper were the most important elements. Carnivorous thousand-legs amounted to three per cent. of the food and insects proper to twenty-one per cent., nearly half of which were ants. But few caterpillars had been eaten by these birds, and only seven per cent. of Coleoptera—five per cent. being Harpalidæ. The lower orders of insects were conspicuous only by their absence.

We are now prepared for the review of the general averages of the season, and the indications which these afford of the economic value of the catbird. Taking the record of the year together as found in the vertical column at the right of the table on pages 125, 126, 127, the seventy birds of the species examined are found to have eaten forty-three parts of insects, two parts of spiders and harvestmen, three parts of thousand-legs and fifty-two parts of fruits. Only thirty-three per cent. of the food consisted of tame fruits, four per cent. being raspberries, twenty per cent. blackberries, one per cent. currants, four per cent. tame cherries, one per cent. strawberries and three per cent. grapes. Scrutinizing more closely the details of the insect food, we find that ants form twelve per cent. of the total for the season; Diptera, chiefly crane-flies, about five per cent.; Lepidoptera six per

cent.; and beetles twelve per cent., one-third of which are Carabidæ. The scavenger beetles and leaf-chafers are three per cent. of the food; plant-beetles, one per cent., and snout-beetles, belonging chiefly to the leaf-eating Brevirostres, likewise one per cent. Two parts of Hemiptera and three of Orthoptera are the only other items that we need notice. It will be seen that ants and beetles occur in about equal ratios, and that these are the most important insect elements in the food. Diptera and Lepidoptera taken together about equal one of the former elements.

Recapitulation.

In the catbird as in the robin the insect averages are highest in the early months, and fall rapidly away from May to July—rising again in August and declining in September. The ratios of insects taken for the five months covered by this table are as follows: 83, 49, 18, 46, 21. The same double curve is especially apparent in the averages of ants, the corresponding ratios for which are 18, 11, 2, 20, 9. Beetles gradually diminish to July and then remain tolerably constant for the season. The predaceous ground-beetles maintain themselves at nearly uniform figures throughout. The Scarabæidæ are, of course, most abundant in May and June, when the leaf-chafers are abroad. The snout-beetles observed were all taken in the months of May and June, and belonged chiefly to species whose injuries are confined to the leaves of trees. Only trifling ratios of plant-beetles were eaten by these birds. Hemiptera also occur in insignificant quantity, the only notable fact being the presence of chinch-bugs in the food of one bird. Orthoptera seemed to be most abundant in the late and early months, diminishing in June and July. Considerable numbers of Arachnida and Myriapoda are eaten by the catbird—a point in which it contrasts notably with the robin. No earthworms were detected in the food. With respect to the fruits taken by this bird, we find that the general ratios for the corresponding months agree closely with those of the robin. Berries of the sumach are eaten in May, but raspberries and blackberries are the most prominent

elements of June, July and August. Wild cherries take the place of these fruits in September, and grapes are then eaten to some slight extent.

A comparison of the statements of this paper with the report published in the Transactions of the Illinois Horticultural Society for 1879, will give some interesting results. The former paper relates to thirty-seven specimens, obtained during the three months of May, June and July; and the present paper relates to seventy birds, taken during five months from May to September. As both the additional months extend the fruit season, we should expect the insect averages would now be smaller than before and that the averages of fruit would show a corresponding increase. This I find to be the principal difference between these tables. The various insect elements stand in about the same ratio to each other as before, except the ants (whose swarming in autumn accounts for their greater prominence in the food), and the Hemiptera and Orthoptera. The first of these orders figures more largely in the general averages for 1880 because this was a "chinch-bug year" in central Illinois; and the second because grasshoppers, locusts and crickets greatly increase in numbers during the later months. In the earlier table, insects amount to fifty-six per cent. of the food; in the later, only to forty-three; ants are respectively ten and twelve, Diptera thirteen and five, Lepidoptera ten and seven, Coleoptera nineteen and twelve, Carabidæ eight and five, leaf-chafers four and three, snout-beetles three and one, Hemiptera one and two, Orthoptera two and three, Arachnida three and two, Myriapoda six and three and the edible fruits twenty-seven and forty-one.

The Catbird and the Robin.

In order to a more exact comparison of the food-habits of the catbird and the robin, I have computed the averages of the principal elements of the robin's food for the period of five months covered by the catbird's record, and give these here alternately with the corresponding averages of the catbird. The ants eaten by the robin

during these months amounted to five per cent. of the food, and those by the catbird to twelve per cent. Diptera were two per cent. and five per cent., Lepidoptera thirteen per cent. and seven per cent., Coleoptera thirteen and twelve, Carabidæ four and five, leaf-chafers three and two, wireworms three and a trace, snout-beetles two and one, Hemiptera three and two, Orthoptera four and three; Arachnida a trace and two, Myriapoda a trace and three; raspberries and blackberries fourteen and twenty-four, cherries eighteen and twelve, currants three and one, grapes eleven and three, and strawberries—none by the robin and one per cent. by the catbird. From this it will be seen that the notable differences in the food-habits of these birds are the much larger ratios of ants, Diptera and berries eaten by the catbird; and of Lepidoptera, wireworms, cherries and grapes eaten by the robin. It also appears that the catbird has a much more hearty appetite for spiders and thousand-legs than the robin.

It is not likely that there is any such active competition for food between these two species as this close agreement in the kinds taken at the same place and season would imply. The stress of the robin's struggle for subsistence evidently comes in early spring, before the advent of the catbird; and by the time the latter appears there is probably an abundance of food for both species. The earlier departure of the catbird likewise prevents any stringent competition in the later months.

Economic Relations.

Remembering that the chief economic service of the robin is done before and after the midsummer wealth of fruits tempts it from the chase of insects, we find it not unreasonable that the catbird, coming later and departing earlier, scarcely anticipating the garden fruits in its arrival and disappearing when the vineyard and orchard are at their best, should be a much less useful bird than its companion. The credit I have given it must be still further reduced because of its serious depredations in the apple orchard. I have often seen it busily scooping

out the fairest side of the ripest early apples, unsurpassed in skill and industry at this employment by the red-headed woodpecker or the blue jay.

At the bottom of the table of food given on page 127 a set of percentages will be seen similar to those previously mentioned in the discussion of the food of the robin. The beneficial elements eaten by this bird, including fruits and the carnivorous insects, run as follows, from May to September: 13, 53, 75, 45 and 19, the average for the season being forty-one per cent. The corresponding ratios of injurious elements are 29, 21, 7, 16 and 4, giving a general average of 15 per cent. for the year. Referring to the vertical column of figures at the right of the table we find the injurious insects of this bird's food as follows: saw-flies one per cent., Lepidoptera seven, leaf-chafers two, snout-beetles one, plant-beetles one, chinch-bugs one and Orthoptera three; while the beneficial insects in the same column are—predaceous beetles five, predaceous Hemiptera one, and Arachnida two. A careful comparison of these elements with each other will probably convince the intelligent reader that these insect averages balance each other fairly well, and that the injury done in the fruit-garden by these birds remains without compensation unless we shall find it in the food of the young. This statement is made upon the hypothesis that ants are to be regarded as neutral insects; and the entire question of the *immediate* value of this species, aside from the still unsettled question of the food of the young, may be reduced apparently to the following form: Will the destruction of a given quantity of ants pay for three times that quantity of the smaller garden fruits?

TABLE OF THE FOOD OF THE CATBIRD. (*Mimus carolinus*, L.)

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL	Ratio of each element to whole of food.
Number of specimens..	..	..	..	..	22	19	11	12	6	..	..	..	07	
KINDS OF FOOD.	Number of specimens and ratio in which each element of food was found													
I. INSECTS..........	..	..	..	..	22 .83	19 .49	10 .18	12 .46	6 .21	..	..	..	69	.43
1. *Hymenoptera*	..	..	..	..	20 .22	13 .12	7 .04	12 .21	6 .09	..	..	..	58	.13
Formicidæ...	..	..	..	..	20 .18	13 .11	4 .02	11 .20	6 .09	..	..	..	54	.12
Ichneumonidæ	..	..	..	..	...	...	...	1 †	...	..	..	..	1	......
Tenthredinidæ	..	..	..	..	2 .02	1 .01	1 .02	...	...	..	..	..	4	.01
2. *Lepidoptera*	..	..	..	..	11 .14	8 .10	1 .03	3 .04	1 .04	..	..	..	24	.07
Caterpillars	..	..	..	..	10 .12	4 .05	...	2 .03	...	..	..	..	16	.04
Noctuidæ	..	..	..	..	1 .02	2 .02	...	1 .02	...	..	..	..	4	.01
3. *Diptera*	..	..	..	..	7 .20	5 .07	...	...	...	..	..	..	12	.05
Tipulidæ	..	..	..	..	6 .19	3 .07	...	...	...	..	..	..	9	.05
Bibionidæ...........	..	..	..	..	...	1 †	...	...	...	..	..	..	1	......
4. *Coleoptera*..........	..	..	..	..	13 .23	18 .17	8 .09	6 .06	4 .07	..	..	..	49	.12
Cicindela..........	..	..	..	..	...	...	1 †	...	...	..	..	..	1	......
Carabidæ	..	..	..	..	7 .09	3 .05	6 .07	2 .01	1 .05	..	..	..	19	.05
Dytiscidæ.........	..	..	..	..	2 .01	...	...	...	...	..	..	..	2	......
Hydrophilidæ.....	..	..	..	..	2 .03	...	...	...	...	..	..	..	2	.01
Staphylinidæ......	..	..	..	..	1 †	1 †	...	...	...	..	..	..	2	......
Phalacridæ........	..	..	..	..	1 †	...	...	...	...	..	..	..	1	......
Nitidulidæ	..	..	..	..	...	1 †	1 †	...	...	..	..	..	2	......
Heteroceridæ	..	..	..	..	1 †	...	...	...	...	..	..	..	1	......
Histeridæ.........	..	..	..	..	3 .01	1 †	...	...	...	..	..	..	4	......
Scarabæidæ.......	..	..	..	..	1 .01	9 .10	3 .03	...	1 .01	..	..	..	14	.03

Table of the Food of the Catbird. *(Mimus carolinus, L.)*—Continued.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total	Ratio of each element to whole of food.
Number of specimens	..	.	..	..	22	19	11	12	6	..	..	..	70	
Kinds of Food.	Number of specimens and ratio in which each element of food was found													
Melolonthinæ	..	..	..	..	1 .01	5 .07	...	...	...	..	..	..	6	.02
Euryomia	..	..	..	..	1 †	...	...	...	...	..	..	.	1	......
Elateridæ	..	..	..	..	1 †	...	...	...	...	..	..	..	1	......
Lampyridæ	..	..	..	..	3 .01	1 †	...	...	...	..	..	..	4	......
Tenebrionidæ	..	..	..	..	1 †	1 †	...	...	...	..	..	..	2	......
Meloidæ	..	..	..	..	...	...	1 .01	...	...	..	..	..	1	......
Rhynchophora	..	..	..	..	6 .05	2 .01	...	...	...	..	..	..	8	.01
Brevirostres	..	..	..	..	4 .04	...	...	...	...	..	..	..	4	.01
Longirostres	..	..	..	..	2 .01	...	...	...	...	..	..	..	2	......
Chrysomelidæ	..	..	..	..	3 .01	2 .01	2 .01	...	...	..	..	..	7	.01
Coccinellidæ	..	..	..	..	...	1 †	...	...	...	..	..	..	1	......
5. *Hemiptera*	..	..	..	..	2 †	2 .01	1 †	7 .07	...	..	..	..	12	.02
Blissus	..	..	..	..	...	...	...	1 .05	...	..	..	..	1	.01
Pentatomidæ	..	..	..	..	2 †	2 .01	...	2 .02	...	..	..	..	6	.01
6. *Orthoptera*	..	..	..	..	6 .04	3 .02	1 .01	5 .07	...	..	..	..	15	.03
Diapheromera	..	..	..	.	1 †	...	...	...	...	..	..	..	1	......
Gryllidæ	..	..	..	..	1 †	...	...	...	...	..	..	..	1	......
Acrididæ	..	..	..	..	3 †	3 .02	...	4 .07	...	..	..	..	10	.02
Neuroptera	..	..	..	..	...	1 †	...	...	1 .01	:	..	..	2	......
II. Arachnida	..	..	..	..	7 .03	3 .03	2 .04	1 †	...	..	..	..	13	.02
III. Myriapoda	..	..	..	..	6 .07	2 .03	4 .04	1 †	2 .03	..	..	..	15	.03
Chilopoda	..	..	..	..	1 †	...	...	...	...	...	..	..	1	......

TABLE OF THE FOOD OF THE CATBIRD. (*Mimus carolinus*, L.)—Concluded.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL	Ratio of each element to whole of food.
Number of specimens..	..	..	..	..	22	19	11	12	6	..	..	..	70	
KINDS OF FOOD.	Number of specimens and ratio in which each element of food was found.													
Diplopoda	..	..	..	..	6 .07	2 .03	4 .04	1 †	2 .03	..	..	..	15	.03
IV. FRUITS	..	..	..	..	2 .07	13 .45	10 .74	12 .54	6 .76	..	..	..	43	.52
Strawberries	..	..	..	..	...	2 .03	...	...	...	..	..	..	2	.01
Raspberries	..	..	..	..	...	9 .21	...	...	...	..	..	..	9	.04
Blackberries	..	..	..	..	...	...	10 .64	8 .35	...	..	..	..	18	.20
Currants	..	..	..	..	...	1 .04	...	...	...	..	..	..	1	.01
Cherries	..	..	..	..	...	6 .16	...	1 .03	3 .40	..	..	..	10	.12
Grapes	..	..	..	..	...	...	...	..	1 .14	..	..	..	1	.03
Sumach	..	..	..	..	2 .07	...	...	...	...	..	..	..	2	.01
Ampelopsis	.	..	..	..	...	...	...	1 .02	1 .04	..	..	..	2	.01
Elderberries	.	..	..	..	...	...	...	...	3 .15	..	..	..	3	.03
	Percentages for each month.													
Beneficial elements	..	..	..	..	13	53	75	45	19	..	..	..	....	41
Injurious elements	..	..		..	29	21	07	16	04	..	..	..	....	15
Neutral elements	..	..	..	..	58	26	18	39	77	..	..	..	....	44

HARPORHYNCHUS RUFUS, L. BROWN THRUSH.

The brown thrush, although not so common a bird as the two preceding species, is still abundant enough to make its habits a matter of economic interest, both to the gardener and the farmer. It is reported by Baird, Brewer and Ridgway to reside and breed all over the United States east of the Rocky Mountains, but in this State it is, like the robin and catbird, practically a strict migrant. Mr. E. W. Nelson reports its occasional occurrence in southern Illinois in midsummer. It reaches Bloomington

a little earlier than the catbird, and, like that species, leaves us in September. It is a shyer bird than either of the preceding, shrubbery and thickets being its favorite haunts and nesting-places.

April.

The record opens with fourteen specimens taken from the 8th to the 28th of April. Five of them were from central Illinois and nine from the northern part of the State in Lake and JoDaviess counties. Fifty-one per cent. of the food of these birds consisted of insects, two per cent. of spiders and six per cent. of thousand-legs. Seven per cent. of the food was Hymenoptera, nearly all ants; five parts were caterpillars and five were grubs of Diptera—apparently crane-flies. Beetles make about one-fourth of the food, and one-fifth of these were Carabidæ. Platynus, Agonoderus and Harpalus were the only genera recognized. A remarkable feature of the food was the occurrence of four per cent. of carrion-beetles, chiefly *Silpha lapponica* and *S. americana*. Thirteen per cent of the food of the month consisted of Scarabæidæ, about three-fourths of these belonging to the genus Euryomia, which eats the leaves of fruit trees later in the season. A few June beetles were also taken at this time. A trace of wireworms, three per cent. of snout-beetles (about two-thirds of them Brevirostres), one per cent. of Hemiptera and two per cent. Orthoptera were the remaining insect elements. We come next to the distinctive feature of the food of this bird among all the thrushes. Forty-one per cent. of the food consisted of seeds and fragments of grain, of which about one-seventh was acorns taken by woodland specimens, and nearly all the remainder corn. The appearance and odor of the contents of these stomachs left no doubt that the fragments mentioned were picked from the excrement of animals.

May.

The month of May is represented also by fourteen specimens, taken at various dates from the 1st to the 27th, chiefly early in the month. Eleven of these were shot in the northern part of the State, between Galena and Wau-

kegan. The large percentage of insect food in May reminds us of the corresponding rise, in this month, of the insect averages of the food of the robin and the catbird. Seventy-nine per cent. of the food of these birds consisted of insects proper, only one per cent. of spiders and three per cent. of thousand-legs. Ants now amount to four per cent., caterpillars to twelve per cent. (one-third of them distinguishable as cutworms), and Coleoptera to precisely one-half the food, one-tenth of it being Carabidæ.

Scarabæidæ rise to thirty-five per cent., chiefly June-beetles of the genus Lachnosterna, wireworms to three per cent. and Hemiptera and grasshoppers likewise to three per cent. The Hemiptera were all soldier-bugs. Among the predaceous beetles Pterostichus, Anisodactylus and Harpalus were recognized. A single specimen of *Cytilus sericeus* was the only representative of the family Byrrhidæ found in the food of any of these birds. Corymbetes and *Monocrepidius auritus* were among the spring-beetles taken. In this month, as in the preceding, the snout-beetles were chiefly Brevirostres. The Scarabæidæ included *Onthophagus hecate, Aphodius fimetarius, inquinatus* and *granarius*, and *Euryomia inda*. Seventeen per cent. of the food of the month consisted of fragments of grain.

June.

The birds of June, fifteen in number, taken from the 1st to the 29th, all from the northern part of the State but two, had eaten about equally of insects and vegetable substances. Ants rise in this month to eleven per cent., caterpillars fall to three, about one-third of these being cutworms. Diptera fall to one, and Coleoptera to twenty-seven per cent., and Carabidæ drop likewise to four per cent. Scarabæidæ return to seventeen, thirteen of these being leaf-chafers; wireworms fall to one, snout-beetles rise to four, and plant-beetles are represented by a single *Chrysomela suturalis*. Among the snout-beetles occur *Sphenophorus parvulus* and *S. sculptilis*. Several specimens of *Epicærus imbricatus* were eaten by three birds. *Phanæus carnifex, Onthophagus hecate* and *Aphodius*

fimetarius appear among the Scarabæidæ. The commencement of the fruit season is here distinctly discernible. Twenty-two per cent. of the food of these birds consists of raspberries, five per cent. of strawberries and one per cent. of cherries, making a total of twenty-nine per cent. of fruits. Fragments of corn and oats amount to nineteen per cent.

July.

But seven birds were examined in July; all from the vicinity of Normal. All of these had eaten insects, which amounted to only about one-fourth of the food. Both ants and caterpillars were present in trifling quantity. Only about half as many Coleoptera had been taken as in the month preceding. Hemiptera and Orthoptera each make up four per cent. of the food, and Arachnida and Myriapoda are entirely wanting. Carabidæ stand at four per cent., as in June, spring-beetles continue at three and snout-beetles amount to two per cent. *Evarthrus colossus* was found among the Carabidæ. *Heteraspis pubescens*, *Colaspis brunnea* and *Diabrotica* 12-*guttata* represented the plant-beetles. The fruits of July amounted to sixty-two per cent. of the food—all blackberries. Twelve per cent. consisted of fragments of corn.

August.

Twelve birds were shot in August, all from McLean county, at various times in the month from the 7th to the 30th. The insect averages rally again in August, returning now to fifty-one per cent. Hymenoptera rise to fourteen per cent.—the highest average of the season—a fact due doubtless to the swarming of certain species of ants at this time of the year.

Caterpillars amount to eleven per cent. of the food; Coleoptera fall away to ten, and all but one of these are Carabidæ. *Cratacanthus dubius* seems to be especially abundant in the later summer and early autumnal months. Four per cent. of the food of these birds consists of this species, and it has likewise been found prominent in the food of the bluebird and the catbird at the same season of the year. A small percentage of snout-

beetles and plant-beetles call for no special remark. Hemiptera now make one-tenth of the food—an exceptional occurrence due to the fact that this was one of the chinch-bug years in central Illinois and that three of these birds had eaten freely of that insect. Orthoptera stand at six per cent., about equally distributed between the three families of the crickets, locusts and grasshoppers. A specimen of Tridactylus was noticed among the first and one of the common katydids among the second. The fruits of this month amount to thirty per cent., eaten by nine of the birds. Half of these were cherries, and the remainder were blackberries, grapes, elderberries, and the berries of the mountain-ash. Fragments of corn amounted to eighteen per cent. of the food.

September.

But two birds were shot in September, too few to give any correct idea of the food of the month. It is only necessary to say that these had eaten more largely of grasshoppers than the birds of the preceding month, and to about the same extent of fruits, all of which were grapes.

Summary for the Year.

Taking the food of the year together, we find that almost precisely one-half of it consisted of insects. Spiders amounted to but one per cent. and thousand-legs to but three. The remainder of the food consisted equally of the smaller garden fruits and the fragments of seeds and grain. Thirteen per cent. of the food of these sixty-four birds consisted of blackberries, four per cent. of raspberries, one per cent. of strawberries and three per cent. of cherries. The ants of the year stand at seven per cent., caterpillars at six, and Diptera at only one. Coleoptera amounted to precisely one-fourth of the food, predaceous beetles to six per cent. and Scarabæidæ to thirteen per cent., nearly all of these being leaf-chafers. Spring-beetles and snout-beetles each average two per cent., and Hemiptera and Orthoptera each stand at four.

In the paper previously cited, published in the Transactions of the Illinois Horticultural Society for 1879, I

gave a table of the food of this species based upon twenty-eight specimens shot in April, May, June and July. A test of the substantial correctness of the conclusions of the present paper may be made by comparing the averages of the table printed herewith with the table on page 150 of the Transactions cited. If the important ratios of the present table, covering the food of sixty-four specimens, shot during six months of the year, agree substantially with that table of the food of twenty-eight specimens, covering but four months of the year, this will be sufficient evidence of their general correctness. I will give these averages alternately, first for the former table and then for the present. The twenty-eight specimens of 1879 had eaten insects to the amount of fifty-nine per cent., and sixty-four specimens of the table of 1880 had eaten insects to the amount of fifty-one per cent. Hymenoptera are seven in the first and eight in the second; ants are seven in the first and also in the second; Lepidoptera seven and seven, Diptera a trace and one, Coleoptera twenty-nine and twenty-five, Carabidæ six and six, Silphidæ two and one; leaf-chafers nine and ten, spring-beetles one and two, snout-beetles three and two. Hemiptera two and four, Orthoptera four and four, Arachnida one and one, Myriapoda four and three, and fruits twenty-two and twenty-four. A larger percentage of Hemiptera is due to the much greater abundance of chinch-bugs in 1880.

Recapitulation.

The brown thrush, arriving in April, finds nearly one-half of its food in fragments of corn and other grains and seeds picked from the droppings of animals. This curious habit it maintains throughout the year, evidently taking this food from preference as well as from necessity. In fact I have often found these vegetable fragments associated with blackberries in the food.

After April this element averages about sixteen per cent. throughout the season. Insects amount to about half the food for each month, except in May when they rise to three-fourths and in July when they drop to one-fourth. The excess in May occurs at the time of the

greatest number and activity of the beetles, and the diminution in July coincides with the period of the greatest abundance cf the small fruits. One-half the insects eaten are beetles, which stand at one-fourth of the food in April and June, rise to one-half in May and fall to about one-eighth in July and August. Half the beetles of the year are Scarabæidæ, chiefly June beetles and Euryomia, all taken previous to July. Nearly one-fourth of the beetles are Carabidæ, which remain at about five per cent. of the food, except in May, when they rise to ten per cent. Although the ratios of spring-beetles and snout-beetles are but two per cent., the numbers eaten are of some significance. My notes show that these birds were eating each at the daily rate of about 1½ curculios, and consequently had averaged a total of about 250 to each thrush for the season. The brown thrush takes ants more freely than the robin, but eats comparatively few caterpillars; seven per cent. of each were found in the food of the year. Diptera are taken in very trivial quantity and Hemiptera in moderate number only. This bird eats thousand-legs more freely than the robin, especially in the early spring. In the garden it plays a part very similar to that of the other thrushes, but is less mischievous, on the whole. Its average of the edible fruits for June, July and August is thirty-eight percent. as against sixty per cent. of the robin and forty-nine per cent. of the catbird. It relishes the whole list of garden fruits, and later in the season resorts, like the other thrushes, to the wild fruits of the woods and thickets. Compared with the robin, this bird is seen to be especially peculiar in the coprophagous habit already mentioned as distinguishing it from all the other thrushes. It takes about one-half as many Lepidoptera, about half as many again Coleoptera, nearly twice as many Carabidæ and three times as many leaf-chafers; but eats comparatively few grapes and cherries. From the catbird it is further distinguished by taking half as many ants, a trivial number of Diptera, twice as many Coleoptera and twice as many Carabidæ, five times as many leaf-chafers and more spring-beetles, snout-beetles, Hemiptera and Orthoptera.

It eats two-thirds as many berries and one-third as many cherries and grapes as the catbird.

Economic Value.

Compared with the robin for corresponding months, this species seems to show very similar economic relations. In both, the totals of beneficial elements eaten during this period are to the injurious about as four to three; but with the brown thrush as with the catbird, its later arrival and earlier departure are to its disadvantage. Balancing as carefully as I can its seven parts of Lepidoptera, ten of leaf-chafers, two of spring-beetles, two of snout-beetles, one of chinch-bugs and four of Orthoptera on the one hand, against its six parts of Carabidæ, two of predaceous Hemiptera, one of spiders, one of predaceous thousand-legs and twenty-one of small fruits on the other, I cannot see that, so far as the *immediate* consequences of its food habits are concerned, it does more good than harm. In short, its Orthoptera must pay for its garden fruits; that is to say, eliminating these two elements, I judge that the predaceous insects eaten would destroy during the year about as many injurious insects as the bird itself has taken. However, I must repeat the suggestion that they could hardly destroy the *same kinds* as the bird, and that, if allowed to live, they would probably decimate some species already sufficiently restricted by existing checks, and permit an unrestrained increase of others now kept down by the thrush. That the disturbances thus set up would soon lead us to regret this bird if its numbers were greatly lessened, is therefore very probable, and I believe the species should be preserved. We must not overlook the special services of the brown thrush in devouring a much larger number of June-beetles than any other of the species examined.

TABLE OF THE FOOD OF THE BROWN THRUSH. (*Harporhynchus rufus*, L.)

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL	Ratio of each element to whole of food.
Number of specimens..	..	..	..	14	14	15	7	12	2	..	..	..	64	
KINDS OF FOOD.	Number of specimens and ratio in which each element of food was found													
I. MOLLUSCA	..	..	..	...	1 †	...	...	1 †	..	..	..	..	2	†
II. INSECTA...........	..	..	..	14 .51	14 .79	15 .49	7 .26	12 .51	..	..	..	..	62	.51
1. *Hymenoptera*	..	..	..	9 .07	10 .04	11 .12	4 .02	11 .14	..	..	..	..	45	.08
Formicidæ...	..	..	..	8 .06	10 .04	10 .11	3 .02	11 .14	..	..	..	..	42	.07
Ichneumonidæ	..	..	..	2 †	...	1 †	...	...	..	..	..	..	3	....
2. *Lepidoptera*	..	..	..	6 .05	12 .12	6 .03	2 .03	7 .11	..	..	..	..	33	.07
Caterpillars	..	..	..	6 .05	12 .12	4 .02	...	7 .11	..	..	..	..	29	.06
Noctuidæ	..	..	..	...	4 .04	2 .01	...	...	..	..	..	..	6	.01
3. *Diptera*	..	..	..	1 .05	...	2 .01	...	...	..	..	..	..	3	.01
4. *Coleoptera*...........	..	..	..	12 .26	14 .50	14 .27	7 .13	9 .10	..	..	..	..	56	.25
Carabidæ	..	..	..	9 .05	7 .10	5 .04	3 .04	5 .09	..	..	..	..	29	.06
Silphidæ..........	..	..	..	3 .04	...	...	...	...	..	..	..	..	3	.01
Nitidulidæ.........	..	..	..	...	...	...	1 .02	...	..	..	..	..	1	†
Staphylinidæ......	..	..	..	...	1 †	...	...	...	..	..	..	..	1	†
Histeridæ.........	..	..	..	2 †	3 .01	1 †	...	1 †	..	..	..	..	7	†
Byrrhidæ	..	..	..	...	1 †	...	...	...	..	..	..	..	1	†
Scarabæidæ.......	..	..	..	9 .13	11 .35	8 .17	...	1 †	..	..	..	..	29	.13
Melolonthinæ ...	..	..	..	2 .01	6 .26	4 .13	...	...	..	..	..	..	12	.08
Euryomia........	..	..	..	2 .09	2 .03	...	...	...	..	..	..	..	4	.02
Buprestidæ.......	..	..	..	...	...	1 †	...	...	..	..	..	..	1	†
Elateridæ.........	..	..	..	1 .01	8 .03	3 .01	3 .03	...	..	..	..	..	15	.02
Tenebrionidæ.....	..	..	..	...	...	...	1 .01	...	..	..	..	..	1	†

Table of the Food of the Brown Thrush. (*Harporhynchus rufus*, L.) Continued.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total	Ratio of each element to whole of food.
Number of specimens..	..	..	..	14	14	15	7	12	2	..	..	..	64	
Kinds of Food.	Number of specimens and ratio in which each element of food was found													
Lampyridæ	..	..	..	...	...	1 †	...	...	..	..	..	...	1	†
Rhynchophora	..	..	..	7 .03	5 .01	7 .04	3 .02	3 .01	..	..	.	...	25	.02
Brevirostres	..	..	..	3 .02	...	3 .02	1 .01	2 .01	..	..	..	...	9	.01
Longirostres	..	..	..	3 .01	1 †	2 .01	...	1 †	..	..	..	...	7	†
Brenthidæ	..	..	..	...	...	1 †	...	...	..	..	..	...	1	†
Chrysomelidæ	..	..	..	...	...	1 †	2 .01	1 †	..	..	..	...	4	.01
5. *Hemiptera*	..	..	..	3 .01	6 .03	1 .01	5 .04	6 .10	..	..	..	...	21	.04
Blissus	..	..	..	...	...	...	...	3 .06	..	..	..	...	3	.01
Pentatomidæ	..	..	..	...	6 .03	1 .01	3 .02	...	..	..	..	...	10	.01
6. *Orthoptera*	..	..	..	1 .02	4 .04	3 .05	2 .04	4 .06	..	..	..	...	14	.04
Gryllidæ	..	..	..	...	...	...	1 .02	1 .02	..	..	..	...	2	.01
Locustidæ	..	..	..	...	...	...	...	1 .01	..	..	..	...	1	†
Acrididæ	..	..	..	1 01	3 .03	3 .04	...	1 .01	..	..	..	...	8	.02
III. Arachnida	..	..	..	3 .02	1 .01	1 .01	...	...	..	..	..	...	5	.01
IV. Myriapoda	..	..	..	6 .06	7 .03	5 .03	...	1 .01	..	..	..	...	19	.03
Geophilidæ	..	..	..	1 .01	...	...	...	1 .01	..	..	..	...	2	.01
Iulidæ	..	..	..	5 .05	7 .03	5 .03	...	...	..	..	..	...	17	.02
V. Fruits	..	..	..	...	...	9 .29	6 .62	9 .30	..	..	..	...	24	.24
Blackberries	..	..	..	...	...	...	6 .62	1 .05	..	..	..	...	7	.13
Raspberries	..	..	..	...	...	6 .22	...	...	..	..	..	...	6	.04
Strawberries	..	..	..	...	...	3 .05	...	...	..	..	..	...	3	.01
Grapes	..	..	..	...	...	...	...	2 .02	..	..	..	...	2	†

TABLE OF THE FOOD OF THE BROWN THRUSH. (*Harporhynchus rufus*, L.)
Concluded.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL	Ratio of each element to whole of food.
Number of specimens..	..	..	..	14	14	15	7	12	2	..	..	..	64	
KINDS OF FOOD.	Number of specimens and ratio in which each element of food was found.													
Cherries...........	..	..	..	...	...	1 .01	...	3 .15	..	..	..	..	4	.03
Elderberries	..	..	..	...	...	...	...	1 .04	..	..	..	..	1	.01
Mountain-ash......	..	..	..	...	...	...	...	1 .03	..	..	..	..	1	.01
VI. SEEDS AND GRAIN.	..	..	..	12 .41	7 .17	9 .18	1 .12	5 .18	..	..	..	..	34	.21
Acorns............	..	..	..	2 .06	...	...	...	...	..	..	..	..	2	.01
Oats..............	..	..	..	...	...	2 .01	...	...	..	..	..	..	2	†
Corn..............	..	..	..	9 .34	...	6 .17	1 .12	5 .18	..	..	..	..	21	.16
Wheat............	..	..	..	1 .01	...	...	...	...	..	..	..	..	1	†
Buckwheat........	..	..	..	1 †	..	...	...	...	..	..	..	..	1	†
	Percentages for each month.													
Beneficial elements....	..	..	..	9	14	34	70	36	..	..	..	..	....	33
Injurious elements.....	..	..		21	49	25	13	24	..	..	..	..	....	26
Neutral elements......	..	..	..	70	37	41	17	40	..	..	..	..	....	41

TURDUS MUSTELINUS, Gm. WOOD THRUSH.

The remaining members of this family are much less important than the preceding species, and their food is of relatively little interest. I shall therefore treat them much more briefly, especially as I have comparatively few specimens of them. The wood thrush is essentially a woodland bird, but occurs not infrequently in groves and gardens and in other situations where trees and shrubbery are accessible. It reaches central Illinois in April, and retires usually in October, spending its winter in the Southern States. I have studied the food of but twenty-two specimens of this species, ranging from

April to September. Two of these birds were taken in April, five in May, six in June, six in July, two in August and one in September. I shall not attempt to follow the food of the species through these months, or to give its seasonal variations; but will content myself with a general statement of the food of the year as indicated by the contents of the stomachs of these twenty-two birds. Seventy-one per cent. of their food consisted of insects and twenty per cent. of fruit, a small ratio of spiders and mollusks and an unusually large percentage of Myriapoda making up the remainder. The four higher orders of insects occur in about equal quantities, the proportion of ants and crane-flies being extraordinary. Blackberries, strawberries, cherries and gooseberries appear among the fruits. Myriapoda amount to twelve per cent.—nearly all Polydesmus and Iulus. The two parts of Arachnida included a few harvest-men. Orthoptera and Hemiptera are respectively six and one per cent.; and snout-beetles and wireworms thirteen per cent. A few June-beetles had been taken, and one of the birds from northern Illinois had stuffed itself with rose-beetles (*Macrodactylus subspinosus*). Geotrupes and Onthophagus were noticed among the other Scarabæidæ. The Carabidæ amounted to six per cent. of the food, including Evarthrus, Pterostichus, Harpalus, Anisodactylus and Bradycellus. Coleoptera make eighteen per cent. of the food and Diptera twelve per cent., chiefly crane-flies and the larvæ of *Bibio albipennis*. Lepidoptera were taken in about the same amount, one-third being recognized as cutworms, while ants reached the unusual average of fifteen per cent. *Helix labyrinthica, Pupilla fallax* and a few other univalve mollusks made one per cent. of the food. Compared with other Turdidæ we find the general insect average unusual, exceeding that of the robin. It agrees with, and even surpasses, the catbird in its preference for ants; and with the robin in the ratios of Lepidoptera, Diptera, Coleoptera, Carabidæ and Scarabæidæ. It differs from the robin in its taste for ants and in the smaller ratio of fruits; and far surpasses all the other thrushes in the number of

Myriapoda eaten in spring. In fact, the midsummer fruits seem to replace these spring Myriapoda, instead of insects proper as in the species already discussed. This bird apparently contrasts more directly with the brown thrush in food than with any other member of the family. The large percentage of Orthoptera is misleading, being due to the fact that a single bird had taken nothing but grasshoppers and locusts. This species seems to do more good and less harm than the preceding thrushes, having the lowest fruit ratio and eating the highest number of insects, with only the average of predaceous species. Its advances, therefore, are to be cordially encouraged by the gardener and farmer—a fact which must be especially agreeable to every lover of bird music, who has learned to recognize the full, clear, rich and exquisite strains of this songster.

HYLOCICHLA PALLASI, Cab. HERMIT THRUSH.

The hermit thrush is strictly a migrant, passing us in May and October. It is reported by Mr. Ridgway as a rare winter resident in southern Illinois, but otherwise appears in the State only during its passage to and fro. Considering the fact, however, that all these birds travel slowly the whole length of the State, merely keeping pace with the advancing and retreating seasons, and also that the species is a very abundant one at the period of the migrations, it will be seen that its food has great economic significance. There is reason to suppose that these migrants, in passing north and south, follow, year after year, about the same route; do not vary, that is, far to the east or west. Consequently, occupying as we do a state that lies in five and one-half degrees of latitude, we can do much to protect this species in its wanderings, or can, if we choose, almost entirely eliminate that part of it passing over our territory. Twenty-one hermit thrushes were taken during the year, two in October and the remainder during the spring migrations. All but five of these birds were shot in extreme northern Illinois, at Waukegan, Evanston and Blue Island. Eighty-four per cent. of the food consisted of insects, four per cent. of

spiders and twelve per cent. of thousand-legs. Ants amounted to fifteen per cent., Lepidoptera to nineteen per cent., including a few Phalænidæ, and Diptera only to three—chiefly the larvæ of Bibio. Coleoptera make thirty per cent. of the food, eleven per cent. being Carabidæ. *Dyschirius globulosus*, Platynus, Evarthrus, Pterostichus, Amara, *Anisodactylus discoideus*, Bradycellus and Stenolophus are mentioned in my notes. Four per cent. are water-beetles, five per cent. scavenger-beetles, two per cent. curculios and two per cent. plant-beetles. Leaf-chafers and spring-beetles amount to one per cent. each —the latter chiefly of the genus Melanotus. *Lixus concavus* and *Listronotus inæqualipennis* occur among the curculios, and *Chrysomela suturalis*, *Gastrophysa dissimilis* and *Plagiodera viridis* among the plant-beetles. Eight per cent. of the food was Hemiptera, nearly all of which were predaceous. *Podisus spinosus* was the only species determined. Grasshoppers (Tettix and Tettigidea) make seven per cent. of the food. Respecting the number of beetles eaten by this bird, we have to remember that it passes us at the time of that great outpouring of insect life connected with the pairing of the spring Coleoptera which we have already seen to have a very significant relation to the food of birds. It rides northward, in fact, on the crest of this Coleopterous wave, and we find the same excess of predaceous Coleoptera in its food which occurs in the food of the other thrushes at the same season. Concerning the two October specimens taken in northern Illinois I need only say that they had eaten ants, caterpillars, Carabidæ, curculios, Pentatomidæ and Orthoptera, spiders, Iulidæ and the larvæ of Bibio. The habits of this bird suggest that the principal drain on the numbers of predaceous beetles may be due to the depredations of the migrants, at the season of the greatest exposure of these insects; and that the complete destruction of resident birds would affect the number of these carnivorous insects much less than would at first seem likely. The reader curious to see the points in which this species contrasts with the other thrushes, may consult the table of the food of the family on page 147.

TURDUS ALICIÆ, Bd. ALICE THRUSH.

The Alice thrush is a bird of frequent occurrence during the migrations. It breeds far to the north, rare summer stragglers occurring in northern Illinois, according to Mr. E. W. Nelson, and probably winters quite beyond our limits. By Dr. Coues this is regarded merely as a variety of the following species. I have ten specimens of this bird shot in May, but none from the fall migration. This number is probably sufficient, however, to give a fairly correct idea of its food in spring. Five per cent. of the food of the month consisted of mollusks, chiefly Succinea and *Helix labyrinthica;* ninety-three per cent. was insects and nearly half of these were ants, which reached the astonishing ratio of forty-three per cent., eaten by every one of the birds. Fifteen per cent. of the food was caterpillars; nine per cent. consisted of crane-flies and their larvæ; Coleoptera amounted to eighteen per cent. (one-half Aphodiidæ), and the remainder were wire-worms, curculios and plant-beetles. Carabidæ amounted only to one per cent., the lowest average of these beneficial insects found in the food of any thrush. Among the species of Coleoptera we find *Stelidota geminata, Onthophagus janus, Conotrachelus anaglypticus, Chrysomela suturalis* and *C. similis.* Grasshoppers make three per cent. of the food and Myriapoda two per cent., all *Polydesmus serratus* and undetermined Iulidæ. Of spiders merely a trace was found in the stomachs of two birds. The striking feature of the food of this bird is evidently its enormous appetite for ants, its high insect average and the almost total absence of beneficial elements in its food giving to this little thrush an enviable status in relation to the farm and garden.

TURDUS SWAINSONI, Cab. SWAINSON'S THRUSH.

This is a migrant of which I have too few specimens for generalization. Six in April and May were taken at Warsaw, Waukegan and Normal, and five in September from the vicinity of Cairo, in extreme southern Illinois, and northern Kentucky. The food in spring is very like that of the preceding species, its especial features being the large number of ants and caterpillars and Coleoptera. The September specimens, on the other hand, were

feeding largely upon fruits, which constituted sixty per cent. of their food. Wild grapes, wild cherries, elderberries and blackberries were all eaten by them, grapes alone making more than half their food. Hymenoptera amounted to nineteen per cent. of the whole; ants to seven, caterpillars to twelve, crane-flies to four, and Coleoptera to eighteen per cent.; five per cent. were Carabidæ (including Anisodactylus), three per cent. were leaf-chafers and two per cent. were curculios. One of the birds, taken at Warsaw in April, had eaten little else than *Scolytus muticus.* Two per cent. of the food was Hemiptera, chiefly Pentatomidæ and Reduviidæ; Rhynchophora and Hemiptera made two and one per cent. respectively. Of spring-beetles and Aphodiidæ, only a trace had been eaten by two of the birds.

Mimus polyglottus, L. Mocking-bird.

This famous bird, not many years ago regarded as a rarity in the State, is evidently becoming more abundant, and is also extending its habitat northward. Collectors in the southern part of the State agree to its increasing numbers there. Three specimens were seen this year in the vicinity of Bloomington, two of which were secured. One of these, shot in August, was of this year's brood, and as the other two seemed thoroughly habituated, it is likely that they had nested in this vicinity this season. It may be worth while to note that sixty per cent. of the food of these two specimens consisted of Orthoptera, including the climbing cricket (Œcanthus). Besides these, they had eaten spiders and harvest-men, Coleoptera, Hemiptera and ants. Among the Coleoptera were specimens of Onthophagus, *Epicauta vittata* and long-snouted curculios. The Hemiptera were undetermined Coreidæ and Pentatomidæ. These birds had not eaten fruit, although the species is reported to be especially fond of grapes.

Conclusion.

As a very general statement of the peculiarities of the food of the resident species, we may say that the robin is characterized by its destruction of caterpillars (especially cutworms) and the larvæ of Bibio, by its neglect of

ants, spiders and Myriapods, and by its taste for blackberries, grapes and especially cherries; that the catbird is distinguished by the large number of ants, blackberries and cherries eaten, and by the small number of insects generally, and of Lepidoptera, Coleoptera and Hemiptera in particular; that the brown thrush is noted for its coprophagous habit, for the small number of caterpillars and Diptera taken, for the large percentage of phytophagous Scarabæidæ and the moderate ratio of small fruits; and that the wood thrush differs from the others chiefly in the large percentage of insects (especially ants, caterpillars and crane-flies), its indifference to Hemiptera and preference for Orthoptera and Myriapoda, and its smaller ratios of fruits.

The migrants can be properly compared only with the residents during the migrating season. I have consequently made a table of the percentages of the food of the four resident species for April and May in comparison with the spring food of the three migrants. From this we learn that the hermit thrush is distinguished at this season by the moderate ratio of ants and Coleoptera, the large number of Lepidoptera, Hemiptera, Orthoptera, spiders and Myriapoda, and the small percentage of Diptera taken. The Alice thrush eats mollusks, an enormous number of ants, a moderate number of Lepidoptera, Diptera and Scarabæidæ, and a small number of Carabidæ and Coleoptera generally, while Hemiptera are almost wanting in its food. Swainson's thrush takes large ratios of ants, Lepidoptera and Coleoptera, and small ratios of Hemiptera, Orthoptera, Arachnida and Myriapoda. It is not to be supposed that the number examined of the last two species is sufficient to give more than an approximate and doubtful outline of the food.

Indeed the reader may not unlikely receive with incredulity the precise statements made concerning the food characteristics of the resident species, and ask how it can be known that these peculiarities are specific and constant instead of local and accidental. To this very reasonable query I am able to make a definite answer. In the paper already frequently cited, I published a comparative table of food of the species of this family, based on

the contents of the stomachs of one hundred and forty-nine birds,* upon which table certain differences of food are clearly shown. Now, if these differences were local and accidental, they would undoubtedly tend to disappear when larger numbers of specimens were examined; but if they are specific and constant, they should be made the more evident, on the whole, the larger the number of specimens taken. The table on page 147 presents data derived from three hundred and fifteen specimens, covering considerably more time and area than the table in the Transactions. If the difference between the food records of the various species are now greater than before, we may conclude that the differences noted are real and not artificial. If they are less, on the other hand, the whole question is still unsettled. The differences apparent in the later table may be specific, but there is no proof of it. In order to apply this crucial test as fully as possible, I have selected twelve food elements in which the differences were most apparent, and, taking the species in pairs, have ascertained the sum of the differences of the ratios of these elements for each pair separately, first from the old table and then from the new. In every case but one the sum of these differences has been much larger by the new table than by the old, thus proving conclusively that the species appear to diverge in food habits the more widely the greater the number of specimens studied. For example, the differences of the selected elements as shown in the original table of seventy-eight robins and catbirds, amounted to sixty-four per cent.; and by the new table of one hundred and eighty-four birds, to eighty-two per cent. A similar comparison of the food of the catbird and hermit thrush gives one hundred and twenty-five as the sum of the differences of the old table of fifty-five birds, and one hundred and fifty-five as the sum of the differences of the new table of ninety-one birds. Taking the catbird and the brown thrush, we have sixty-four and ninety-nine parts for the old and new tables respectively, the first for sixty-five birds and the second for one hundred and thirty-four; while the brown thrush and wood thrush give seventy-eight and eighty-

* Trans. Ill. Hort. Society, 1879, N. S., Vol. 13, p. 163.

eight parts for thirty-nine and eighty-six birds respectively, and the catbird and wood thrush give seventy parts for eighty-five birds and eighty-three parts for ninety-two birds. It is not until we reach the last two migrants that we find any exception to these results; and of these, as already said, probably too few have been examined, even yet, to justify settled conclusions.

Finally, we must consider the family as a unit, must discuss the actual effect of the thrushes as a group upon the plants and animals of the State. A determination of this interesting question involves three elements; the average character of the food of each species as shown by the preceding calculations, the comparative abundance of the species, and the length of its stay in Illinois. I find the estimates of the second of these elements, as made by various collectors, to differ rather widely; and on this account only an approximate conclusion can be reached. Using the figures most satisfactory to myself, I present the following as a tolerably fair statement of the general food of the family: Sixty-one per cent. of the food consists of insects, one per cent. of spiders, two per cent. of Myriapods, and thirty-two per cent. of fruits, eleven per cent. being blackberries, eight per cent. cherries, one per cent. currants and five per cent. grapes. The fragments of grain eaten by the brown thrush will amount to four per cent. of the food of the family, and ants compose eight per cent. Lepidoptera, Diptera and Coleoptera are eaten in about equal ratios, the first forming thirteen, the second eleven and the third twelve per cent. of the entire food. Carabidæ amount to five per cent., June beetles to four per cent., wireworms to two per cent. and snout-beetles to two per cent. Hemiptera stand at three per cent., about two-thirds of them predaceous, and Orthoptera at four per cent. Five per cent. of the food was recognized as cutworms. More briefly, thirty parts of the food consist of injurious insects, including the larvæ of Bibio, and eight parts of beneficial species, while twenty-six parts consist of edible fruits; or we may say that injurious insects compose about one-third, the edible fruits about one-fourth and the beneficial insects about one-twelfth of the food of the family, the remaining elements being of neutral value.

TABLE OF THE FOOD OF THRUSHES IN APRIL AND MAY.

	Robin	Catbird	Brown Thrush	Wood Thrush	Hermit Thrush	Alice Thrush	Swainson's Thrush
No. of specimens examined	31	22	28	8	18	10	6
KINDS OF FOOD.	Ratio in which each element of food was found.						
1. MOLLUSCA	.01	....	....	†	....	.05	....
2. INSECTA	.93	.83	.65	.84	.87	.95	.98
Hymenoptera	.03	.22	.05	.20	.16	.47	.31
Ants	.03	.18	.05	.20	.13	.43	.28
Lepidoptera	.24	.14	08	.21	.19	.15	.22
Noctuidæ	.09	.02	.04	.08	....	.02	....
Diptera	.12	.20	.03	.15	.01	.09	.07
Tipulidæ	.03	.19	....	.15	....	.08	.07
Bibionidæ	.04	....	....	....	....	....	....
Coleoptera	.43	.23	.38	.23	30	.18	.30
Carabidæ	.11	.09	.07	.09	.11	.01	.05
Scarabæidæ	.19	.01	.24	.06	.06	.10	.06
Coprophagous	....	....	....	....	.05	.10	....
Phytophagous	.12	.01	.19	.02	.01	....	.06
Elateridæ	.04	†	.02	.06	.01	.02	†
Rhynchophora	.03	.05	.02	.02	.02	.03	.03
Chrysomelidæ	.01	.01	....	....	.02	.01	.02
Hemiptera	.04	†	.02	.01	.08	....	....
Predaceous	.03	†	.02	....	.06	....	....
Herbivorous	....	....	....	....	....	....	....
Orthoptera	.05	.04	.03	.03	.08	.03	....
3. ARACHNIDA	.01	.03	.02	.01	.04	†	.01
4. MYRIAPODA	.01	.07	.04	.13	.09	.02	.01
5. FRUITS AND SEEDS	.03	.07	....	....	....	....	....
6. FRAGMENTS OF GRAIN	....	....	.29	....	....	....	....

TABLE OF FOOD OF FAMILY TURDIDÆ. (THE THRUSHES.)

	Robin	Catbird	Brown Thrush	Wood Thrush	Hermit Thrush	Alice Thrush	Swainson's Thrush	Mocking-bird	TOTAL	Corrected average
No. of specimens examined	114	70	64	22	21	11	11	2	315	..
KINDS OF FOOD.	Ratio in which each element of food was found.									
1. MOLLUSCA	....	....	....	....	....	.05	....	...	...	...
2. INSECTA	.65	.43	.51	.72	.84	.93	.62	...	...	.61
Hymenoptera	.04	.13	.08	.15	.16	.47	.19	...	...	.09
Ants	.04	.12	.07	.15	.13	.43	.17	...	...	.08
Lepidoptera	.17	.07	.07	.13	.18	.15	.12	...	...	.13
Noctuidæ	.08	.01	.01	.04	....	.04	....	...	...	.05
Diptera	.17	.05	.01	.12	.04	.09	.04	...	...	.11
Tipulidæ	.01	.05	....	.12	....	.08	.04	...	...	.03
Bibionidæ	.15	....	....	....	....	....	....	...	...	.07
Coleoptera	.18	.12	.25	.18	.29	.18	....	...	...	.12
Carabidæ	.06	.04	.06	.06	.14	.01	.05	...	...	.05
Melolonthidæ	.03	.02	.10	.03	.01	....	.03	...	...	.04
Elateridæ	.02	....	02	.03	.01	.02	†	...	...	.02
Rhynchophora	.02	.01	.02	.03	.03	.10	....	...	...	.02
Chrysomelidæ	....	.01	†	....	.02	.01	....	...	...	...
Hemiptera	.03	.02	.04	.01	.10	....	.02	...	...	.03
Predaceous	.02	.01	.01	.01	.07	....	.01	...	...	.02
Herbivorous	....	.01	.01	....	....	....	.01	...	...	...
Orthoptera	.04	.03	.04	.06	.07	.03	.01	...	...	.04
3. ARACHNIDA	.01	.02	.01	.01	.04	....	.02	...	...	.01
4. MYRIAPODA	....	.03	.03	.07	.12	.02	.01	...	...	.02
5. FRUITS	.34	.51	.24	.19	....	....	.35	...	...	.32
Strawberries	....	.01	....	....	....	....	....	...	...	...
Blackberries	.09	.24	.17	....	....	....	†	...	...	.11
Cherries	.11	.12	.03	....	....	....	.06	...	...	.08
Currants	.02	.01	....	....	....	....	....	...	...	.01
Grapes	.07	.03	†	....	....	....	.27	...	...	.05
6. FRAGMENTS OF GRAIN	....	....	.21	....	....	....	....	...	...	.04

Family SAXICOLIDÆ. (The Stonechats.)

SIALIA SIALIS, L. THE BLUEBIRD.

This beautiful and beloved bird, endeared to the student of nautre by every particular of its plumage, song and way of life, is also one of the most popular of all birds with farmers and gardeners. Living under the eyes of men from the first yielding days of the later winter until the year grows chill and dark with the retreat of autumn, it has been praised most warmly for its tireless service of man by those who knew it best. A cursory observation of its feeding habits will strongly support the general impression of its usefulness. Most frequently it takes a short, quick flight to the ground from a fence-post or a low branch of a tree, and, after a moment's pause, returns to its perch with a caterpillar or a grasshopper or some other insect in its beak, which it devours at its leisure, repeating this operation so frequently that none can doubt its enormous destructiveness to insect life.

It is true that a little reflection will suggest that, as it evidently sees its prey before it leaves its perch, it must usually take only the most conspicuous and the most active insects, and that there is no security that these will be the most injurious—that they may not be, in fact, among the most beneficial; but this consideration does not seem to have made any impression, and the bluebird remains to this day substantially without reproach.

I have now examined carefully, with the microscope, the contents of one hundred and eight stomachs of this species, of which ten were taken in February, twenty-one in March, thirteen in April, nine in May, ten in June, nine in July, twelve in August, ten in September, two in October and twelve in December (in southern Illinois). I propose to present the data for each of these months; to summarize them for the year; to estimate the benefit and injury indicated to farm and garden, and to make a comparison of the food of this bird with that of the robin, and of the thrushes generally.

February.

The ten birds of this month were all shot at Normal, Ill., from the 24th to the 29th of the month, in the present year. These stomachs, with those obtained from Galena, in early March, represent the first food of the season.

The record opens with a bird shot on the 24th. Thirty per cent. of its food had been grass-eating cutworms, forty per cent. crickets (*Gryllus abbreviatus*), five per cent. Ichneumonidæ (*Arenetra nigrita* Cress.), and twenty-five per cent. the larvæ of the two-lined soldier-beetle (*Telephorus bilineatus*). Now, the ichneumons are doubtless parasitic, although about the habits of the genus Arenetra, I have at present but little specific information; and the soldier-beetles are reported by Prof. Riley and others to be highly useful insects, noted especially for the destruction of the apple-worm and the eggs of grasshoppers.*

Taking the month together, we find that the most important elements of the food were cutworms and ichneumons—twenty-four per cent. of the former to twenty-two per cent. of the latter. The larvæ of the soldier-beetles amount to eight per cent., locusts (chiefly the young of *Tragocephala viridifasciata*) to nine per cent., Carabid beetles and their larvæ (including Amara and Anisodactylus) to five per cent., Pentatomidæ or soldier-bugs (chiefly *Euschistus servus*) to seven per cent., spiders to four per cent. and Iulidæ (thousand-legs) to three per cent. Other items are, two per cent. caterpillars of Arctians (*Callimorpha lecontei*), four per cent. crickets, and nine per cent. dung-beetles (*Aphodius fimetarius* and *A. inquinatus*). The ichneumons, Carabid beetles, soldier-bugs and spiders thus make up forty-six per cent. of beneficial insects, while the caterpillars and Orthoptera amount to but forty-one per cent. of injurious species. Or, if we drop the Pentatomidæ from the former category, on account of the supposed trifling injuries to vegetation done by some of them (hence often called "plant-bugs"), the figures will stand, beneficial insects thirty-nine, to forty-one injurious.

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* See 4th Rep. State Ent. Mo., p. 29, and Rep. U. S. Ent. Comm., 1877, p. 302.

March.

Twenty-one specimens were examined which had been shot in this month, in 1880, ranging from the 7th to the 31st. Seven of these were shot at Normal, nine at Heyworth (fifteen miles south) and five at Galena, in extreme northwestern Illinois. These latter differed from the central Illinois specimens chiefly in the presence of the dried and sometimes mouldy fruit of the sumach (*Rhus glabra*) in their stomachs, indicating a scarcity of desirable food at that early season. One of these, unfortunately for the record of the month, had stuffed itself with larvæ of Harpalus, which made ninety-three per cent. of its food.

Ichneumonidæ (Arenetra) appear again (four per cent.), for the last time during the season.

Harpalid beetles and their larvæ were unusually abundant, making up eleven per cent. of the food of the month. Among these Platynus, Evarthrus, Pterostichus, Amara, *Chlænius tomentosus,* Agonoderus and Harpalus were recognized. The larvæ of soldier-beetles also occur, constituting four per cent. of the food, but do not appear again throughout the year. Four birds had eaten a predaceous bug (*Coriscus,* near *ferus*),* which is too minute to figure in the ratios; and four per cent. of the food was Pentatomidæ, of which only *Peribalus modestus* was recognizable. Sixteen of the twenty-one birds had eaten spiders, making five per cent. of the food. The beneficial insects thus amount to twenty-eight per cent. On the other hand, thirty-eight per cent. was caterpillars, chiefly Noctuidæ,† including *Callimorpha lecontei* and the army-worm (*Leucania unipuncta*); one per cent. was *Euryomia inda,* and twenty-one per cent. was Orthoptera (crickets and grasshoppers), the injurious species thus rising to sixty per cent. One bird had also eaten a minute curculio. Among neutral elements we enumerate Aphodii three per cent., Iulidæ three per cent., and sumach berries four per cent. Two birds had eaten ants, but in trivial quantity.

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* Kindly identified for me by Mr. Uhler.

† I have thus reported all smooth caterpillars in which the cervical an anal shields, common to most cutworms, were distinguished. A few su caterpillars are not Noctuids, but are equally injurious.

In order to determine the number of specimens which it is necessary to examine in each month, to reach reliable averages of benefit and injury, I divided my notes on twenty of the specimens for March into two groups of ten each, so selected that all the localities and all parts of the month were equally represented in each group; and then averaged each ten separately and compared the averages. In the first group beneficial insects composed twenty-nine per cent of the food, and injurious insects fifty-nine per cent.; in the second group beneficial insects composed twenty-seven per cent. of the food and injurious insects sixty-one per cent. The close correspondence of these averages shows that, on this question, ten specimens would have given as accurate information as twenty, and indicates that ten birds a month will usually afford a fair basis for an opinion.

April.

The food for April, as shown by the thirteen specimens of that month (from Normal, Evanston, Waukegan, and Elizabeth, in 1876 and 1880), was remarkable for the number of Aphodii (dung-beetles) it included; twenty-one per cent. of the food of the month was *Aphodius inquinatus,* nine per cent. *A. fimetarius,* and one per cent. undetermined Aphodii. This peculiarity is accounted for, in harmony with what has been said above respecting the feeding habits of the bluebird, by the fact that this is the month when the Aphodii fly most actively in the latitude of northern Illinois. Carabidæ now stand at eight per cent., including *Carabus palustris,* Pterostichus, Evarthrus, and other Pterostichi, Platynus, *Chlænius tomentosus, Anisodactylus rusticus, Amphasia interstitialis,* and Harpalus: four per cent. of Hemiptera includes Coriscus and *Hymenarcys nervosa,* while spiders rise to nine per cent. Caterpillars are twenty-one per cent. (seventeen per cent. Noctuids), June-beetles (Phyllophaga) two per cent., Curculionidæ one per cent., and grasshoppers (Tettigidea sp. and *Tettix ornata*) eight per cent.; a total of thirty-two per cent. of injurious insects against twenty-one per cent of predaceous species. Among the

neutral elements we find a sprinkling of ants (two per cent.), larvæ of a Tenebrionid (*Merancantha contracta**) four per cent., and thousand-legs (Iulidæ) one per cent. Long strips of grass, in pieces much too large to have been eaten by any of the insects present, were found in the stomachs of two of these birds, and also occurred during each of the three following months. I am in doubt whether these were taken as food; but, since I have found them in no other bird, and since a species which feeds so largely on cutworms and grasshoppers may have acquired the power of digesting the very considerable quantities of grass contained in the intestines of these insects, I have thought it best to include them in the percentages of food. It is probable, however, that they were swallowed accidentally with insects taken from the ground.

It will be noticed that the excess of Coleoptera in April is largely compensated by the diminished quantities of Orthoptera and caterpillars.

May.

In this month nine birds were taken, from six localities in central and northern Illinois, in 1876–80. The Lepidoptera, Coleoptera and Orthoptera return to about their normal ratios, but spiders rise to the excessive figure of twenty-one per cent. This ratio is, however, partly misleading, as, although six of the nine birds had eaten spiders, yet eleven per cent is due to a single bird, which had eaten nothing else. In such a case a larger number of specimens is required to restore the balance, so violently disturbed. Two birds of this month had eaten moths, and five had eaten cutworms. The averages stand fifty-five per cent. of moths, caterpillars, June-beetles, curculios and Orthoptera, opposed to thirty-five per cent. of Carabidæ, soldier-bugs and spiders. The Carabidæ include *Cratacanthus dubius*, *Agonoderus comma*, Anisodactylus, and Harpalus. Other details may be obtained from the table at the close of this paper.

* For the determination of this species and most of the other larvæ which have been identified specifically, I am under obligations to Professor Riley.

June.

In June ten birds—one from Mt. Carroll, the others from Normal—had taken a somewhat unusual diet. The ratio of spiders (eighteen per cent.) falls a little short of that for May, but an examination of the notes shows that here, too, a single bird had eaten nothing else. Ants rise suddenly from two per cent. in May, to twenty per cent. in June, taken by six of the birds. Most of these, however, were of the winged forms, and their number is evidently due to the same cause which rendered the Aphodii so abundant in April. Three of the birds of June proved, to my surprise, to have eaten raspberries, and one gooseberries—these fruits amounting to eight per cent. of the food of the month. No cutworms were recognized in June, but measuring-worms (Phalænidæ) replaced them, composing six per cent. of the food. While all the cutworms found in any month whose food was at all distinguishable had eaten nothing but grass—or endogenous foliage, more accurately speaking—several of these Phalænidæ had been feeding on net-veined leaves. The Harpalinæ (six per cent.) include Evarthrus sp., *Pterostichus lucublandus* and *Anisodactylus baltimorensis*. June-beetles (Phyllophaga) had been eaten by one bird, and a Melanotus, a curculio, and a long-horn beetle (*Tetraopes tetraophthalmus*,) each by one. Pentatomidæ reach five per cent., chiefly *Hymenarcys nervosa*, and Orthoptera fall to three per cent. The excess of ants is therefore taken, like the excess of Aphodii, from the caterpillars and grasshoppers.

The averages of beneficial and injurious species stand thirty per cent. to twenty-six per cent., respectively. Regarding ants, I find such conflict of opinion among good authorities, that I am not able to give them a definite place on either side of the line. The injury to fruits is probably too insignificant to be taken into account, except as evidence that the species is not strictly insectivorous, even in midsummer.

July.

The nine birds of this month were all shot in central Illinois, during four successive years. Besides the return

of the percentages of Hymenoptera, Coleoptera, Lepidoptera and Arachnida to about their usual figure, we notice the large ratios of June-beetles (twelve per cent.) and Orthoptera (twenty-seven per cent.). The latter includes seven per cent of *Udeopsylla nigra,* a large cricket-like locust. We find also a trace of raspberries in the food of two individuals. The caterpillars eaten by these birds were unrecognizable, except those from a single stomach, which Prof. Riley has identified as *Nephelodes violans,* Guen. The record of benefit and injury is now more favorable to the species—sixty-seven per cent. of injurious insects, and only fourteen per cent. beneficial, the latter Carabidæ and spiders.

August.

Twelve specimens were obtained in August at Normal, three early in the month and the others on the 29th and 30th. The bluebirds were at this time most abundant in meadows and pastures; and the contents of their stomachs indicate that the chief business of the month was the pursuit of locusts, crickets and grasshoppers, moths and caterpillars. The Orthoptera eaten by these birds amounted to fifty-eight per cent. of their food, and the Lepidoptera to twenty-seven per cent. About half of the former were Gryllidæ (Gryllus and Nemobius), and the remaining half were equally Locustidæ and Acrididæ (*Xiphidium fasciatum* and *ensifer, Caloptenus femur-rubrum* and *bivittata,* and *Œdipoda sordida*). Half of the Lepidoptera were unrecognizable moths and the remainder caterpillars—five per cent. being Noctuidæ. Ants were about one per cent. of the food, Coleoptera only five per cent. (including three per cent. Harpalidæ), Pentatomidæ (*Cœnus delius*) one per cent. and spiders six per cent. A few wild cherries and elderberries were the only fruits taken. The beneficial elements thus amounted to nine or ten per cent. of the food and the injurious elements to about eighty-five per cent.

September.

All but one of the ten specimens upon which the account of the September food is based were shot at Normal, and

all but two on the 29th of the month. The chief peculiarity of the month is the almost total disappearance of Coleoptera, which were represented only by a few small Harpalids and a single minute Atænius. The Lepidoptera rise to thirty-seven per cent., chiefly through the abundance of the larvæ of *Prodenia lineatella,* Harvey. The Orthoptera make nearly half the food, the species differing from those of the preceding month mainly in the greater number of red-legged grasshoppers. Spiders were only two per cent. of the food; and some unknown wild fruits formed seven per cent. It will be seen that a striking change in the food of this species attends that increase of the Orthoptera in numbers and activity which occurs in the late summer and early autumnal months, these insects being almost entirely substituted for Coleoptera, Hemiptera and Arachnida. The Coleoptera of the six preceding months averaged twenty-seven per cent. of the food, while this order amounts to but three per cent. in August and September. The Orthoptera of the foregoing months averaged but fourteen per cent., while those of the two months in question rise to fifty-four per cent. It is evident from the foregoing that Orthoptera and smooth caterpillars are the favorite autumnal food of this bird, and as the first of these remain abundant until frost, it is not likely that the food of October is much less favorable to the bird than that of September. The two specimens taken in the former month were well filled with winged ants.

December.

To learn the food of the bluebird in midwinter, I went to extreme southern Illinois in December, 1879, and shot a number of specimens, some from the heavy forests in the bottoms of the Ohio River, and others from the wooded and cultivated highlands in Pulaski county. The weather at this time was sometimes above and sometimes below freezing, and bluebirds were abundant and very much at home. The principal food of the twelve specimens examined consisted chiefly of various wild fruits (eighty-four per cent.), of which the berries of the mistletoe (*Phoradendron flavescens*) were the most abun-

dant (fifty-eight per cent.). Grapes, the berries of sumach, scarlet thorn (Cratægus) and holly (*Ilex decidua*) were also found. Sixteen per cent. of the food was insects, of which the larger part (ten per cent.) was the larva of Harpalinæ—eaten, however, by but two of the birds. Prominent among these was the larva figured and described by Professor Riley in the Report of the United States Entomological Commission for 1877, p. 290, and there doubtfully referred to *Harpalus herbivagus*. The remaining kinds were *Geotrupes blackburnii, Podisus spinosus*, a single spider, and one unknown caterpillar. Even in the dead of winter, therefore, this bird does not cease its warfare on our predaceous bugs and beetles.

Summary for the Year.

To these figures, giving the averages for all the months mentioned taken together (except October), I invite special attention. Being derived from a much larger number of specimens than any of the monthly averages, they are much less likely to be affected by accident or error. They give, furthermore, the basis for an estimate of the total effect of the bird, year after year; and from this we should be able to predict the probable effect of a destruction or diminution of the species.

Taking up first the injurious insects destroyed, we find that these include twenty-six per cent. of Lepidoptera, nearly two-thirds of which were recognized as *Noctuidae*, three per cent. of leaf-chafers and twenty-one per cent. of Orthoptera—a total of fifty per cent. on this side of the account. On the other hand, the ichneumons amount to three per cent., the Carabidæ to seven per cent., soldier-beetles to one per cent., soldier-bugs to three per cent. and spiders to eight per cent.—a total of twenty-two per cent. of predaceous and parasitic forms. Other elements are ants four per cent., Diptera only a trace, Aphodii six per cent., Iulidæ one per cent. and vegetable food thirteen per cent. The edible fruits amount only to about one per cent. of the food of these one hundred and eight specimens. Comparing with the Turdidæ, we find that the bluebird is essentially a thrush in food. From the robin it differs principally in the larger number of Hymenop-

tera (seven to four) and Lepidoptera (twenty-six to seventeen), the lack of Diptera (robin seventeen per cent.), the excess of Aphodii (six to two), of Pentatomidæ (robin one per cent.), of Orthoptera (twenty-one to four) and of spiders (eight to a fraction); but especially in the matter of edible fruits (one to thirty-four). These differences are but little greater, however, than those among the thrushes themselves. Compared with the thrush family as a whole, its salient peculiarities are its neglect of Diptera and garden fruits and its preference for Lepidoptera, Orthoptera and spiders.

Economic Relations.

Mr. B. D. Walsh, the first State Entomologist of Illinois, reasoning from the comparative numbers of injurious and beneficial insects, concludes that a bird must be shown to eat at least thirty times as many injurious individuals as beneficial before it can be considered useful.*

According to this estimate, the bluebird does at least thirteen times as much harm as good; that is to say, the beneficial insects eaten would themselves have destroyed thirteen times as many injurious insects as the birds have eaten. This conclusion is so unexpected and astonishing that it certainly cannot pass without careful examination. In the first place we should bear in mind that nothing has yet been learned of the food of the young, and there is some reason for supposing that birds select the softer insects for their young. Whatever deficiency of credit may be due to this neglect of the food of the young is compensated in part, at least, by the fact that the number of caterpillars eaten is doubtless overestimated in comparison with hard insects, as their flexible skins remain in the stomachs of birds longer than the hard structures of insects. This is exactly contrary to the usual supposition, but the frequent occurrence of the empty and twisted skins of cutworms in the stomachs of these birds, still recognizable as Noctuidæ when not even a fragment of a single head remains, is sufficient evidence that the hard parts break up and disappear

* "Birds vs. Insects." Practical Entomologist, Vol. II, pp. 44-47.

before these delicate but yielding skins. Secondly, while our knowledge of the food of Arctians, cutworms and grasshoppers is sufficiently definite and full to enable us to predict with certainty exactly what would happen if those eaten by bluebirds were allowed to live and multiply, we have not the same complete and certain knowledge of the food habits of the different genera of Ichneumonidæ, the ground-beetles, the soldier-bugs and soldier-beetles.

One hundred bluebirds, at thirty insects each day, would eat in eight months about 670,000 insects. If this number of birds were destroyed, the result would be the preservation, on the area supervised by them, of about 70,000 moths and caterpillars (80,000 of them cutworms), 12,000 leaf-chafers, 10,000 curculios and 65,000 crickets, locusts and grasshoppers. How this frightful horde of marauders would busy itself if left undisturbed, no one can doubt. It would eat grass and clover and corn and cabbage, inflicting an immense injury itself, and leaving a progeny which would multiply that injury indefinitely. On the other hand, would the 160,000 predaceous beetles and bugs, spiders and ichneumons either prevent or compensate these injuries. I do not believe that we can say positively whether they would or not.

In a discussion of the natural checks upon the cutworms Professor Riley, in his First Report as State Entomologist of Missouri, mentions two species of Ichneumon that parasitize the larva, credits the spined soldier-bug and the Carabid larva, *Calosoma calidum,* with its destruction, and says that some kinds of spiders are known to prey upon it.

From the Report of the United States Entomological Commission for 1877, we learn that the grasshopper is preyed upon at one or the other stage by Agonoderus, Harpalus, Amara and other Carabids; by soldier-beetles, soldier-bugs and spiders; and that certain Ichneumonidæ parasitize the egg. It seems *probable,* therefore, that the beneficial insects eaten by bluebirds include the special enemies of the cutworms and grasshoppers it destroys; but he who knows best the small number of reliable obser-

vations upon which our general statements of the food of predaceous insects rest, will have the most hesitation in trusting them without reserve.

I would also call attention to the fact that we do not yet know that the normal rate of increase among these carnivorous and parasitic insects is not sufficient to keep their numbers full to the limit of their food supply, and to furnish also a *surplus* for destruction by birds. Just as a tree puts forth more leaves than it needs, and sets more fruit than it can possibly mature, as an offset to the constant, normal depredations of insects, so there is much reason to suppose that our insect friends have become adjusted to this steady drain on their numbers.

TABLE OF THE FOOD OF THE BLUEBIRD. (*Sialia sialis*, L.)

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL.	Ratio of each element to whole of food.
Number of specimens......	...	10	21	13	9	10	9	12	10	2	...	12	108	
KINDS OF FOOD.	Number of specimens, and ratio in which each element of food was found.													
I. INSECTS..................	...	10 .92	21 .88	13 .88	9 .76	9 .71	9 .89	12 .91	10 .91	...	...	5 .16	98	.78
1. *Hymenoptera*..........	...	7 .22	5 .04	5 .02	3 .02	7 .21	6 .04	4 .01	4 .04	...	...	...	41	.07
Formicidæ.............	...	...	2 †	5 .02	3 .02	6 .20	6 .04	4 .01	4 .04	...	...	...	30	.04
Ichneumonidæ.........	...	6 .22	2 .04	...	...	...	...	...	...	...	...	...	8	.03
2. *Lepidoptera*...........	...	8 .28	20 .38	9 .21	7 .39	5 .13	7 .27	7 .27	7 .37	...	...	1 .02	71	.26
Arctiinæ................	...	1 .02	4 .04	...	...	...	...	...	...	...	...	...	5	.01
Noctuidæ..............	...	6 .24	11 .39	5 .17	3 .19	...	1 .10	2 .05	4 .14	...	...	...	32	.12
Phalænidæ............	...	...	...	...	...	2 .06	...	...	...	...	...	...	2	.01
3. *Diptera*...............	...	1 †	1 .01	1 †	...	1 †	...	...	...	...	...	...	4	...
4. *Coleoptera*............	...	9 .22	16 .19	13 .51	8 .18	7 .28	10 .26	7 .05	4 .02	...	...	4 .13	78	.20
Carabidæ..............	...	6 .05	16 .10	10 .08	5 .12	3 .06	4 .09	6 .03	2 .01	...	...	2 .10	54	.07
Dytiscidæ............	...	...	...	...	...	1 .01	...	...	...	...	...	...	1	...
Staphylinidæ..........	...	...	...	1 †	...	...	...	...	...	...	...	...	1	...
Histeridæ.............	...	...	1 †	1 †	...	...	...	...	...	...	...	...	2	...
Byrrhidæ..............	...	...	...	1 .01	...	...	...	...	...	...	...	...	1	...
Scarabæidæ...........	...	3 .09	4 .04	10 .33	2 .05	5 .12	3 .14	3 .02	1 †	...	...	1 .03	32	.09
Aphodius..............	...	3 .09	2 .03	10 .31	1 .03	4 .04	...	...	1 †	...	...	...	21	.06
Geotrupes............	...	...	...	...	...	...	...	...	...	...	...	1 .03	1	...
Phyllophaga..........	...	...	...	1 .02	1 .02	1 .08	2 .12	...	...	...	...	...	5	.03
Euryomia............	...	...	1 .01	...	...	...	...	...	...	...	...	...	1	...
Elateridæ.............	...	...	1 †	...	...	1 .01	...	...	...	...	...	...	2	...
Tenebrionidæ..........	...	...	...	1 .04	...	...	...	...	...	...	...	...	1	...

TABLE OF THE FOOD OF THE BLUEBIRD. (*Sialia sialis*, L.)—Concluded.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	TOTAL	Ratio of each element to whole of food.
Number of specimens	...	10	21	13	9	10	9	12	10	2	...	12	108	
KINDS OF FOOD.	Number of specimens, and ratio in which each element of food was found.													
Telephorus	...	3 .08	2 .04	...	...	...	...	...	...	...	...	...	5	.01
Curculionidæ	...	1 †	1 †	3 .01	2 .01	1 .01	3 .01	...	...	...	...	...	11	....
Cerambycidæ	...	...	...	...	...	1 .01	1 .02	...	...	...	...	...	2	....
Tetraopes	...	...	...	...	...	1 .01	1 .02	...	...	...	...	...	2	....
5. *Hemiptera*	...	4 .07	10 .04	7 .04	2 .02	3 .05	2 .05	1 .01	1 †	...	...	1 .01	31	.04
Coriscus	...	...	4 †	1 .01	...	...	...	...	...	...	...	...	5	....
Alydus	...	...	...	...	...	...	1 .04	...	...	...	...	...	1	....
Pentatomidæ	...	3 .07	7 .04	4 .02	2 .02	3 .05	1 .01	1 .01	...	...	...	1 .01	22	.03
6. *Orthoptera*	...	7 .13	13 .21	5 .08	6 .13	2 .03	5 .27	12 .57	9 .48	...	...	...	59	.21
Gryllidæ	...	1 .04	2 .03	...	1 .02	...	1 .01	6 .28	2 .11	...	...	...	13	.05
Locustidæ	...	...	...	...	...	...	1 .07	4 .15	1 .02	...	...	...	6	.03
Acrididæ	...	6 .09	11 .18	5 .08	5 .11	2 .03	5 .19	4 .14	6 .33	...	...	...	44	.13
II. ARACHNIDA	...	6 .04	16 .05	9 .09	6 .21	5 .18	2 .05	6 .06	3 .02	...	...	1 †	54	.08
III. IULIDÆ	...	6 .04	8 .03	2 .01	1 .01	...	2 .02	...	...	...	...	...	19	.01
IV. VEGETABLE FOOD	...	...	3 .04	4 .02	3 .02	5 .11	6 .04	3 .03	1 .07	...	...	12 .84	37	.13
	Percentages for each month													Ratios.
Beneficial elements	...	46	28	21	35	*38	14	10	03	...	...	11	...	22
Injurious elements	...	41	60	23	55	26	67	80	85	...	...	02	...	49
Neutral elements	...	13	12	56	10	34	19	10	12	...	...	87	...	29

* Includes 8 per cent. fruit.

NOTES UPON THE FOOD OF PREDACEOUS BEETLES.*

BY F. M. WEBSTER.

Pliny thought it nothing to the credit of the philosophers of his day, that while they were disputing about the number of heroes by the name of Hercules, and the site of the sepulcher of Bacchus, they should not have been able to decide whether or not the queen bee possessed a sting.[1]

While the problem of the bee sting has long been decided, and heroes by the name of Hercules have ceased to trouble the minds of men, there are problems of vital importance regarding the habits of the insects which, during the greater portion of the year, we meet daily in abundance, that still remain unsolved.

The most important as well as the most abundant of these insects are the beetles.

While found in almost every conceivable situation, while our naturalists count the species in their cabinets by the thousands, it would be difficult to point out a single species, the food habits of which we *fully* understand, when both the larvæ and imago state are taken under consideration.

True, we have a sort of ritual laid down by entomologists, based upon the fact that certain species have been known to feed upon certain substances, but this can no more be considered as proof that nothing else enters into their natural diet, than does the meat of which we may partake at dinner prove us to be strictly carnivorous, or the bread or fruit, that we are exclusively vegetarians.

An illustration of this double diet of beetles is found in the case of the European *Silpha opaca*, Linn., the larva of which has been known to feed to an injurious extent upon the leaves of the beet and mangel-wurzel.[2]

But one of the most fortunate in getting the benefit of our ignorance is the family Carabidæ, to utter a word against which is almost considered a sacrilege.

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* Although this paper does not belong with the studies made at the Laboratory, but is based entirely upon the author's personal observations, it is included with this series, with his permission, because it relates to the same subject. These observations precede, in point of time, those of the following paper.—S. A. F.

[1] Pliny, Hist. Nat., l. xi, c. 17.

[2] Curtis, "Farm Insects," p. 388.

But, true to the adage "murder will out", occasionally a species is found feeding upon vegetation with a voracity that would do credit to a Chrysomelid. Of these in Europe, besides the *Zabrus gibbus* in both stages, some of the Pterostichi, Amaræ, Omophron and *Calathus latus* Westw., are said to injure grain by eating off the young shoots or destroying the seed.[3]

Two species of Bembidium (*lampos* and *monticola*) have been destructive to the forests of upper Austria.[4]

Broscus cephalotes attacks the growing grain, and *Aristus bucephalus* devours the seeds of grass.[5]

In our own country the *Omophron labiatum* Fab. injures the shoots of young corn in the Southern States.

Harpalus caliginosus Fab. is suspected of feeding upon grain in stack in Maryland, and also of eating timothy seeds from the heads.[6]

E. T. Dale, of Jasper, Mo., forwarded to the editors of the American Entomologist specimens of an insect found by him feeding upon the seeds of a plant unknown to him. Upon examination they proved to be *H. caliginosus*.[7]

According to Mr. Mather, of Marshalltown, Iowa, the larvæ of some species of Harpalus are destructive to his evergreens, he having found them eating off the roots.[8]

The foregoing is a synopsis of all facts relating to the vegetable-feeding Carabidæ, so far as known to the author of this paper. A number of years ago the writer commenced the study of the food of beetles, correctly judging from what was then known, that either naturalists were in error in their suppositions or else that innocent insects were wrongly accused. And he is free to confess his partiality to the former theory as being the most correct. But after several years of study and observation, I have found to my astonishment not only the species accused but others also of this family feeding largely upon vegetable substances, both useful and noxious. Among my earliest observations on this subject I

[3] Report U. S. Agr. Dept., 1868, pp. 79-80.
[4] Deutsche Entomologische Zeitschrift, 1879, p. 417.
[5] Westwood's Introduction, I, p. 61.
[6] Report U. S. Agr. Dept., 1868, p. 80.
[7] Am. Ent. Vol. I, p. 80.
[8] Am. Ent. Vol. III, p. 26.

noted the abundance of Carabidæ about the shocks of wheat in a field where a violent wind storm had blown down a large number of sheaves, under which, upon their being replaced, large numbers of *Harpalus caliginosus, pennsylvanicus* and *herbivagus, Pterostichus lucublandus* and *Anisodactylus baltimorensis* were observed.

The wheat was drawn in and threshed directly from the field, and a large percentage of the kernels were badly eaten. Previous to the threshing, in another field, a specimen of *H. pennsylvanicus* was captured with a partially eaten grain of wheat in its mandibles. The eaten grains of the threshed wheat seemed to agree with the fragments found in the jaws of the beetle, and as no other destructive agencies were noted, the facts seemed to suggest that the damage was done by the before-mentioned Carabidæ. A few days after, *H. pennsylvanicus* was found eating the now fully ripe seeds from a head of upright timothy grass, and was observed to detach them from the glumes. The same species has since been seen feeding largely upon ragweed, *Ambrosia artemisiæfolia* Linn., during September, the seeds apparently being the favorite part. A short time after it was found upon timothy grass it was observed eating the seeds of prairie grass, *Panicum crus-galli* L.; and the same day another individual was found devouring an *Ips fasciatus* Oliv., one of the Nitidulidæ, thus proving its carnivorous propensities also. *H. caliginosus* is likewise found eating the seeds of *Ambrosia artemisiæfolia.*

H. herbivagus feeds largely upon the tender shoots of grass during March, cutting them off just below the surface; but later it selects the tender blades and the discolored parts usually found under boards, etc.

Amara angustata Say is found quite abundantly upon the heads of June grass, *Poa pratensis* L. But the most voracious Carabid enemy of this grass is the *Anisodactylus sericeus* Harris.

Early in June, 1878, vast numbers of these beetles were noted upon the heads of this grass; in fact, spots several yards in area were literally covered with them. After patient watching—for they are very timid—the proof

was conclusive that the unripe seeds were what they were after and not microscopic insects as was at first supposed.

The insect is not only cunning, drawing up its legs and dropping to the ground upon the least disturbance, after the manner of a Chrysomelid, but also shows considerable ingenuity. It grasps the lower extremity of the glume tightly in its mandibles, then relaxing slightly, passes upward and again tightens its grasp—a series of movements which finally force the seed, which is now of the consistency of cream, out at the apex. This it at once proceeds to devour with an appetite which reminds one quite forcibly of a tramp who has been obliged to earn his dinner in advance. Later in the season it is found feeding in the same manner upon the seeds of *Agrostis vulgaris* Witt. Specimens of *Anisodactylus baltimorensis* Say were observed feeding upon the marrow and fatty matter clinging to the tibia of some dead animal, probably that of an ox. Attention is called to this as being in perfect accord with microscopic observations reported by Mr. Forbes in the following paper, upon another specimen found upon grass a few months later.

Calathus gregarius Say may be found abundantly upon the heads of timothy grass during the early mornings of the first of July. Of the genus Platynus only a single observation has been obtained, and this was during the latter part of June of the present year, when two specimens of *P. cupripennis* Say were seen harassing a half-grown cricket, which they had already disabled. The carnivorous habits of beetles are often as difficult to discover as their vegetarian. Usually they are not at all in favor of public dinners, and, like beasts or birds of prey, prefer to drag their victims to some secluded nook to devour them; hence, if the observer gets any insight into this part of their domestic affairs he must take them by surprise. In this manner a *Staphylinus cinnamopterus* Grav. was surprised while in the act of devouring an *Anomoglossus pusillus* Say, having first, to guard against its escape, eaten off four of its legs.

In another instance a *Dyschirius globulosus* Say was observed to spring upon a small salmon-colored maggot-

like larva, and, after disabling it, to start off to select a proper place to devour it. After the lapse of several minutes, it returned to drag its victim under a small clod of dirt and leisurely feast upon it.

After the same manner a *Bradycellus rupestris* Say was surprised under a stone while eating a small white thread-like worm.

Another family of beetles whose hitherto almost untarnished reputation it seems to have fallen to my lot to soil is the Coccinellidæ. With the exception of *Epilachna borealis* Fab. the larva of which feeds upon the vines of the gourd family,[9] these insects in our country have been considered strictly carnivorous, although several European species are known to deviate from this rule.

This season, specimens of *Megilla maculata* DeG. have been taken while feeding upon the pollen of the dandelion, *Taraxacum dens-leonis,* and it is not at all improbable that the pollen of other plants also forms a part of their diet, as they are rather common upon the blossoms of plants and fruits.

No accurate estimation of the value of the Coleoptera could be obtained without including the Telephoridæ. Besides *Chauliognathus pennsylvanicus* Forst., which has been found feeding upon the larvæ of the *Conotrachelus nenuphar* Hbst.,[10] and *Telephorus bilineatus* Say, which is such a powerful auxiliary in checking the ravages of the western locust,[11] *Podabrus tomentosus* Say has been observed feeding upon the cottonwood gall-lice, *Pemphigus populivenae* Fitch, and the *P. populicaulis* Fitch. These beetles sometimes place themselves at the opening of the gall, occasionally as many as four together, and catch the mature lice as they attempt an egress, and sometimes plunge their flat head and thorax into the cavity and draw forth and devour large and small indiscriminately. During the latter part of June and the first of July these beetles are very abundant, not only upon trees affected by gall-lice, but upon other plants also.

[9] Am. Ent., Vol. II, p. 373.
[10] Am. Ent., Vol. I, pp. 35 and 51.
[11] Report U. S. Ent. Comm., Vol. I, p. 302.

NOTES ON INSECTIVOROUS COLEOPTERA.

By S. A. FORBES.

Mouth Structures of Carabidæ.

In studying the food of birds, I found it necessary to construct a key to the genera of the Carabidæ, based primarily upon the mouth structures, and prepared for this purpose a large number of slides of the mouth parts of Illinois species. In studying these, two characters were noted, which proved to be of considerable service for classification. The first of these is the frequent obliteration of the suture between the mentum and the gula (called the "gular suture", by Dr. LeConte, in his Classification, Pt. I, pp. X, XIII, 14, 15 and 16), the mentum being, in such cases, connate with the gula. This is true of Blechrus, although in Trechicus and Metabletus of the same group the suture is distinct. The mentum is again connate in many species, at least, of several genera of Dapti and Eurytrichi; viz., Geopinus, Anisodactylus, Xestonotus, Spongopus and Amphasia; but is not connate in Nothopus, Piosoma, Discoderes or Anisotarsus. This character was noticed nowhere else except in *Amara angustata,* which differs in this respect from all the other Amaræ in the Laboratory collection. This species is also peculiar in the very great development of the muscular ridges on the upper surface of the mentum. In the Lebiæ this mental suture is distinct in the middle but obsolete at the ends.

The second character referred to is found in the stipes of the maxilla. This body is covered with three plates—an outer, closely connected with the palpus, a lower, from which the two lobes of the maxilla spring, and an upper plate, which is applied to the under surface of the mandible. The last of these usually presents, in the Harpalidæ, a more or less prominent angle at about the anterior third of the outer margin, although this margin is sometimes regularly curved. In two genera, Agonoderus and Sten-

olophus, this plate is produced forward and outward beyond the articulation with the palpus (which thus seems to spring from beneath it), forming an oblique lamina with a rounded outer angle and an acute tip. This character seems to distinguish Stenolophus from Harpalus, as far as I have been able to compare the species.

Food of the Carabidæ.

The large numbers of Carabidæ eaten by several of our common birds make it important that the somewhat doubtful food habits of this family should be more thoroughly studied; and I have undertaken the microscopic examination of the contents of stomachs and intestines as one branch of this investigation. The facts thus obtainable perhaps cannot give us a complete idea of the food of these insects, but should probably be taken in connection with field observations, as these beetles are said frequently only to suck the juices of their prey, rejecting the solid parts; and where this has been done the fact will be only obscurely indicated by the contents of the alimentary canal. Where this contained an abundance of fatty chyme with no solid tissues to fix its source, I have sometimes doubtfully inferred such an event; but usually liquid food will escape detection.

The results of the examinations thus far made are so interesting that I am impelled to give the method I have found most successful and convenient, with the hope that others may turn their attention to the same subject. The dissection should be made as soon as possible after the beetle is taken—within a few days at farthest—as the more unstable elements of the food are apparently soon changed, even in strong alcohol. If the beetle is as large as *Megilla maculata*, the elytra and wings may be cut off and then, while the insect is held between the thumb and finger of the left hand, the edges of the abdomen may be carefully trimmed away with a pair of fine scissors (those with curved blades are best) leaving the soft dorsal covering attached only at the base and tip. If one blade of the scissors be now carefully passed under this dorsal integument, it may be cut across and reflected (with the

forceps and a mounted needle) forwards and backwards and cut entirely away. It will next be necessary to unroof the meso- and meta-thoracic segments, which usually contain at least a part of the crop. It will not be difficult to cut through the crusts of these segments at each side with the scissors-points. The terga may then be removed as before, with forceps and needle. The specimen (if not too large) should now be transferred to a watch crystal, covered with glycerine and placed on the stage of the microscope; (a dissecting microscope is a convenience, but not indispensable). With mounted needles the reproductive organs, urinary tubes, etc., can be pushed out of the way, when the crop, stomach and intestine will be seen, variously arranged according to the family and genus. It is an easy matter to cut the alimentary canal loose at either end and to remove it from the body, placing it upon a slide in a shallow cell, with glycerine enough to mount the contents. Here the superfluous structures should be picked away, as far as possible, and then the stomach and intestines may be torn open with needles, and their contents spread out and picked in pieces upon the slide. After the removal of the remnants, the cell may be covered and the contents studied with any power necessary. The cover should, of course, be finally cemented down and the slide preserved for verification and repeated examination.

Galerita janus.—A specimen of this insect, taken at Bloomington, in September, contained but little food. All that was recognized consisted of insect fragments, one of which was a spinose tibia. It was impossible even to tell the order of the insect eaten.

Loxopeza atriventris.—Four specimens of this species were examined, three of which were taken in June and the other in September. The alimentary canal of the first was entirely empty. The second, sent me by Mr. A. S. McBride, from DeKalb county, had eaten immense numbers of minute, oval bi-nucleate cells, which, believing them to be spores of fungi, I referred to Prof. T. J. Burrill, of the Illinois Industrial University. He reported them to be "spores of Sphæronemei, probably Phoma"—

a fungus which forms small, black specks on dead wood, stems of weeds, etc. A third specimen from the same source had eaten some undetermined insect and about equal quantities of three elements; viz., the above spores of Phoma, pollen and the anthers of grass (doubtless blue-grass upon which the insect was taken). A few clavate bodies were also noticed, consisting of a single row of nucleated cells—evidently the acrospores of some fungus. A September specimen was taken at Normal. Its crop was distended with an oily liquid, but contained no other visible food except a few acrospores of a fungus. This specimen had evidently been feeding upon animal food of some sort.

Calathus gregarius.—Three individuals of this species were examined, all caught on blue-grass in blossom, by Mr. Webster, of Waterman, and Mr. McBride, of Freeland. The crop and œsophagus of the first were distended with a brown mass which proved to be wholly made up of the pollen and fragments of the anthers of grass. A second specimen contained a smaller amount of pollen and anthers of blue-grass, with minute fragments of a black and sparsely hairy insect. An antenna proved that it was a larva—probably a young caterpillar. The third contained traces of a similar larva and the fragments of the cornea of a perfect insect—evidently a remnant of some former repast.

Anisodactylus baltimorensis.—The single specimen of this species had not recently taken food. The stomach was empty; but in the intestines was a large amount of chyme which possibly indicated liquid animal food. A specimen of *A. rusticus* gave only similar negative results.

Anisodactylus sericeus.—A specimen taken in June showed fragments of anthers and pollen of grass, with other vegetable tissues, apparently derived from the seeds of grass. A small insect had also been eaten, as shown by particles much too few and minute for determination. A second specimen had taken precisely similar food—the insect here being represented by a few facets of the cornea.

Amara angustata.—One of this species, likewise taken in June, had also fed on vegetation, as indicated by a few particles of parenchyma too far digested for recognition; but fully nine-tenths of its food consisted of spherical eggs, in different stages of development, many of them easily recognizable as the eggs of mites. The most advanced embryos had six legs and a pair of large palpi; and, by the shape of the abdomen and the position of the legs, recalled the larvæ of the spinning mites (Tetranychi).

Harpalus pennsylvanicus DeG.—A specimen of this species taken running in the road, at Normal, August 31st had the alimentary canal well filled with vegetable tissues, some of which were evidently derived from the ovules and roots of grass. Among these were the tips of an ovule with the styles unbroken and the tip of a rootlet with the root-cap entire. A single mite was found, and a few acrospores of fungi. This beetles was infested by a large number of intestinal parasites of the genus Gregarina. A second specimen had eaten similar vegetable food. Here a piece of the epidermis of a rootlet, still covered with trichomes, was noted, as well as several root-tips and fragments from the growing tips of grass. Pieces of the epidermis of grass with their peculiar zigzag cell boundaries, confirmed these determinations. A detached stigma of a grass floret and a few stylospores completed the food. A third specimen, taken at Normal on the 5th of September, contained some vegetable tissues with spiral cells, the mandible and maxilla of an ant and vast numbers of minute, spherical corpuscles, which Professor Burrill regarded as forms of bacteria such as occur on stagnant water. This beetle had apparently skimmed this minute vegetation from the surface of some pool. The fourth specimen of this species, received in September, from Mr. Webster, who collected it from the blossoms of ragweed, I found to have eaten large quantities of vegetable tissue, the fragments of which showed branched bundles of spiral ducts with parenchyma between. These were evidently the bracts or other floral organs of the ragweed.

Harpalus caliginosus.—A single individual, running free upon the ground, had gorged itself with plant and animal food—apparently about three times as much of the former as of the latter. In the crop were a few hairs of a caterpillar and much half-digested muscle, with spores of fungi, a little epidermis of some graminaceous plant and a few pollen grains of Compositæ. In the stomach was a great deal of chyme, with fragments of the wings and tarsi of some minute dipter, more pollen of Compositæ and some vegetable parenchyma, apparently derived from unripe seeds of grass. In the ileum and colon these last-mentioned tissues predominated, although the latter contained also a large quantity of pollen of Compositæ indistinguishable from that of ragweed (Ambrosia). Here were also found two feet of a larva—possibly of the previously mentioned caterpillar. It is worthy of notice that these Harpali were full of eggs, of which there were about six in each abdomen. The crop of the second specimen, taken at Normal, in September, was distended with a brown, oily fluid, containing no recognizable material. In the intestine was a small mite and considerable vegetable parenchyma, apparently derived from some young seeds or ovules of plants. A little parallel-veined vegetable tissue was also seen, evidently derived from grass.

Harpalus herbivagus.—A specimen of this beetle, taken by Mr. McBride in July, was filled with cryptogamic vegetation which had the form of a dense mat of slender branching tubes enclosing many spherical cells. This, Professor Burrill, to whom one of the slides of this material was referred, regarded as a fleshy or cartilaginous fungus with Palmella cells, although he thought that it might have been derived from a lichen. A second specimen, obtained by Mr. Webster, in March, had evidently been feeding on the young shoots of grass.

Cratacanthus dubius.—One of this species, taken at Normal, in August, contained no apparent food except a few spores of fungi. In the stomach were great numbers of Gregarina, apparently of the same species as those found in *Harpalus pennsylvanicus.* In the colon, espe-

cially, scores of these parasites in the "resting state" formed considerable masses which half filled the intestines.

Evarthrus colossus.—One of this species, taken in September, had eaten a brown beetle of medium size, the fragments of which filled the whole alimentary canal. From the general appearance of these, from the tips of one anterior and one middle tibia and from a maxillary palpus, it was inferred that this beetle was one of the Scarabæidæ. A fragment of a mandible showing a ridged masticatory surface, made it likely that it was a vegetable feeder. There was no trace of vegetable food in this Evarthrus. Another specimen, taken at Normal, in September, had eaten a large Coleopterous larva and two minute, indeterminable insects. Traces of confervoid Algæ were also discovered in the intestine.

Pterostichus sayi.—A specimen of this species, taken at Normal, in September, was full of the remains of an unrecognized hairy insect with two tarsal claws.

Pterostichus lucublandus.—This specimen, taken likewise at Normal, in September, contained a multitude of fragments of some Hymenopterous insect, including a maxillary palpus and a labrum nearly entire, with pieces of the legs and tarsi. This beetle had also eaten a small mite and a few acrospores of fungi.

Chlænius tomentosus.—One of this species, taken at Normal, in September, contained traces of insect food not otherwise determined, and a nematoid parasite.

Chlænius diffinis.—A specimen of this species, taken under a log, near Normal, in September, contained traces of some crustaceous insect, with pieces of vegetable tissue (apparently wood) penetrated by the mycelium of a fungus. Large vegetable fragments were also seen, which Professor Burrill determined as pieces of a large, fleshy fungus. The stomach likewise contained acrospores of Dematiei.

Bradycellus dichrous.—A specimen, taken at Bloomington, in September, had eaten insect food not otherwise determinable.

Twenty-eight specimens of Carabidæ, representing seventeen species, are here reported. It will be seen that twenty-one specimens, belonging to fifteen species, had eaten animal food, and that twenty specimens, belonging to eleven species, had eaten vegetation of some sort. I estimated as carefully as possible the relative amounts of these two kinds of food in the alimentary canal of each insect, and from these data concluded that about half the food of these twenty-eight specimens consisted of vegetation, and that one-third of it consisted certainly of insects—the remainder being made up of doubtful animal matter. About one-third of the vegetable food had been derived from cryptogamic plants and another from the different structures of grasses, Compositæ and other miscellaneous vegetation making up the remainder. Considering the fact, however, that the commonest species were found feeding upon vegetation far the most generally, it is likely that, taking the Carabidæ as a group, not more than one-third or one-fourth of their average food consists of animal matter.

Food of Podabrus.

The contents of three stomachs of *Podabrus tomentosus* were examined; and all these had eaten only the spores of Phoma mentioned under Loxopeza. The specimens were all sent me in July, by Mr. A. S. McBride, of Freeland, Ill.

Food of Coccinellidæ.

Coccinella novem-notata.—Two specimens which were taken at Normal, in August, were examined, agreeing very closely in their food, each having eaten various spores of fungi (about ninety per cent.) and plant-lice (ten per cent.). Among the fungus spores, Professor Burrill, to whom they were submitted, recognized spores of *Ustilago and Helminthosporium;* and a few lichen spores were also noticed.

Brachyacantha ursina.—The stomach of one individual of this species contained only a few fungus spores.*

* I have assured myself that none of the fungi found in the alimentary canals of these beetles were entophytes.

Hippodamia convergens.—A specimen, captured in August, at Normal, had eaten great quantities of fungus spores, which composed about three-fourths of its food. Fragments of a mite and a plant-louse and a little pollen of Compositæ were also found. In a second specimen, taken in September, the remains of a myriapod belonging to the family Geophilidæ, acrospores of a fungus, the pollen of Compositæ and the remains of a plant-louse were the only elements noticed.

Megilla maculata.—Three specimens of this species were dissected—one received from Mr. Webster in May, one from Mr. McBride in July, and one taken at Normal in September. The specimen from Mr. Webster was captured on the flowers of dandelions. Its entire alimentary canal was closely packed with hexagonal, spinose pollen cells, doubtless taken from that plant. A second had eaten the anthers and pollen of grass with a few spores of Myxogastres.* The third specimen contained pollen and fungus spores in about equal quantities. While these Coccinellidæ had made good their usual reputation as enemies of plant-lice, it should be noticed that these constituted only about ten per cent. of their food.

If these specimens of the various families of predaceous beetles are fair examples of their class, the above facts imply that the individual carnivorous insect is much less valuable than has usually been supposed, while predaceous insects as a class are much more beneficial. If these species are predaceous, as a rule, not more than from one-fourth to one-third of the time, the injury done by the destruction of one of them is very much less than if they were, as is usually supposed, almost wholly carnivorous. But, on the other hand, if they can live on the soft parts of plants when animal food becomes scarce, their numbers will be maintained at a far higher figure than would be possible if they were dependent upon animal food alone. Preferring animal food to vegetable, as they doubtless do when equally obtainable, they operate as a much more effective check on the undue increase of other insects than if their number were at all times strict-

* Burrill.

ly limited by the numbers of their food species. We should remember, in this connection, that we cannot ordinarily expect of any predaceous animal that it will do more than to eliminate the excess of the species it preys upon, keeping their numbers down within certain constant limits. As a prudent sovereign finds it worth while to maintain a much larger fighting force than is necessary to the ordinary administration of his government, in order that he may have always a reserve of power with which to meet aspiring rebellion, so it is to the general advantage that carnivorous insects should abound in larger numbers than could find sustenance in the ordinary surplus of insect reproduction. They will then be prepared to concentrate an overwhelming attack upon any group of insects which becomes suddenly superabundant. It is evidently impossible, however, that this *reserve* of predaceous species should be maintained unless they could be supported, at least in part, upon food derived from other sources than the bodies of living animals.

A

REVISED CATALOGUE

OF THE

BIRDS

Ascertained to Occur in Illinois.

By ROBERT RIDGWAY.

BLOOMINGTON, ILL.:
PANTAGRAPH PRINTING ESTABLISHMENT.
1881.

PREFACE.

The present catalogue, although based essentially upon the list published in 1874, in the Annals of the Lyceum of Natural History of New York (vol. x. pp. 364–94) is rendered much more complete by the addition of nearly thirty species, and many facts which have been brought to light by subsequent investigations. The most important sources from which this additional information has been derived are the several lists of Illinois birds published by my friend Mr. E. W. Nelson,[1] of Chicago (now U. S. Signal Observer at St. Michaels, Alaska), but I have also been furnished with many interesting facts through correspondence with persons actively engaged in the study of the ornithology of the state, among whom I may especially mention Dr. J. W. Velie, of the Chicago Academy of Sciences, Mr. H. K. Coale, of Chicago, and Mr. C. K. Worthen, of Warsaw; the information thus derived being duly acknowledged in the proper places.

To the 311 species of the catalogue of 1874, there are here added 31, which would bring the total number known to occur in Illinois up to 342 were it not for the fact that one species (*Podiceps cristatus*) was included upon erroneous information, and is therefore eliminated. Of the 341 species enumerated herein, no less than 213 are positively ascertained to breed within the limits of the state. Not a single species has been included except upon good authority, while, on the other hand, several are excluded on account of not having been actually captured within the state, though some of them have been secured near Racine, Wisconsin, in the extreme southeastern corner of Wisconsin, rendering it therefore extremely probable that individuals of the species in question have at one time or another

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[1]For the titles of these, see pp. 168–170.

visited Illinois territory. A few species (*e. g. Pica rustica hudsonica* and *Lagopus albus*) are given upon the authority of Mr. Robert Kennicott, but have not been noted by any subsequent observer. They may not now occur in Illinois, but this does not, however, affect the validity of Mr Kennicott's record, which cannot be passed over on the strength of purely negative evidence.

In the catalogue of 1874 I gave a list of 48 species "to be looked for" in Illinois, and which it was stated would "no doubt be yet found to occur within the limits of the state." Of these no less than 15 have already been taken or observed, besides four (*Dichromanassa rufa*, *Ajaja rosea*, *Pelecanus fuscus* and *Stercorarius parasiticus*) whose occurence had not been anticipated. We may therefore look with confidence to the capture of the remaining species of the list, when the extreme southern and northwestern borders of the state have been more thoroughly explored.

As may be seen from an examination of the following catalogue, the avian-fauna of Illinois is exceedingly rich and varied, probably no inland state or territory, not traversed by lofty mountain ranges, being equal to Illinois in this respect. This great richness and diversity of bird-life results primarily from two causes,—the central position of the state geographically, and its great extent from north to south. The variety of surface which the state presents in different sections, notwithstanding the prevalence of large prairies, is also an important factor, no state, perhaps, east of the Pacific slope presenting greater contrasts of this kind. Stretching through nearly six degrees of latitude, the climates of the northern and southern portions are very diverse, the advent of spring, as determined by the first flowering and leafing of identical plants, averaging fully six weeks earlier near the Ohio river than in the vicinity of Chicago.*

§The difference in climate between Cairo and Chicago, as determined by the U. S. Signal Bureau, is as follows:

	An. mean.	Av. of hottest month.	Av. of coldest month.	An. range.	Latitude.
Cairo..............	57.3	80.2 (August.)	31.3 (January.)	....	37.00
Chicago...........	46.7	72.8 (July.)	20 (December.)	....	41° 52'

The two opposite sections of the state also differ essentially in the natural products of the soil,—the southern being clothed with almost continuous forests, which in the bottom-lands are remarkable for massiveness of growth and great variety of species, while in the central and northern portions extensive prairies largely prevail. Indeed, it is difficult to conceive of more complete contrast than that afforded by the cypress swamps, canebrakes, and almost tropical luxuriance of vegetation of the southern bottom forests, on the one hand, and the extensive, monotonous northern prairies on the other. Intervening districts present every conceivable combination of prairie and woodland, while particular sections possess special features, such as the line of high precipitous bluffs along part of the western border, the romantic, almost mountainous range of rugged hills traversing the southern portion, from east to west, and the hilly region northwestward. The prairies of central and northern Illinois being a modified continuation of the "Great Plains," a considerable number of birds characteristic of, or peculiar to, the "Campestrian District," together with others common to the whole of the Western Region, are thus brought into contact with eastern woodland forms; while the proximity of the Great Lakes, on the northeast, secures the presence of many species formerly considered of purely maritime or littoral habitat, but which in reality occur, at one season or another, on many of the larger streams of this inland state. Considering also in this connection the very large preponderance of the southern element in that portion of the state lying south of the parallel of 39° (approximately), and also the influx of northern forms during the winter season, it may be seen that no less than five distinct faunæ overlap on the area included within the boundaries of the state of Illinois,—the eastern, which, in its purity, of course largely predominates; the maritime and littoral, by way of the Great Lakes and the St. Lawrence; the boreal, coming down from the high north in winter; the western, extending eastward across the prairies to the border of the wooded country; and, lastly, the southern, or "Austroriparian" fauna, a very considerable element of which extends up the Mississippi valley to at least the 38th parallel of north latitude.

The bird-fauna of Illinois, as at present understood, embraces members of 17 "orders" (according to the latest and most improved classifications), 51 families, 225 genera, and 339 species. The subjoined tables are intended to show the relative number of species by which each family is represented, in numerical order.

Table of Families of Birds represented in the Avian-fauna of Illinois, given in order of numbers of species.

1. Fringillidæ	41	28. Laniidæ	3
2. Anatidæ	40	29. Ampelidæ	2
3. Mniotiltidæ	37	30. Tanagridæ	2
4. Scolopacidæ	25	31. Cuculidæ	2
5. Falconidæ	24	32. Cathartidæ	2
6. Laridæ	18	33. Columbidæ	2
7. Icteridæ	11	34. Ibididæ	2
8. Strigidæ	11	35. Recurvirostridæ	2
9. Ardeidæ	11	36. Gruidæ	2
10. Tyrannidæ	10	37. Pelecanidæ	2
11. Turdidæ	9	38. Phalacrocoracidæ	3
12. Picidæ	9	39. Stercorariidæ	2
13. Rallidæ	8	40. Ptilogonatidæ	1
14. Vireonidæ	7	41. Certhiidæ	1
15. Troglodytidæ	7	42. Motacillidæ	1
16. Hirundinidæ	6	43. Alaudidæ	1
17. Charadriidæ	5	44. Trochilidæ	1
18. Paridæ	4	45. Cypselidæ	1
19. Corvidæ	4	46. Alcedinidæ	1
20. Tetraonidæ	4	47. Psittacidæ	1
21. Podicipitidæ	4	48. Meleagridæ	1
22. Sylviidæ	3	49. Perdicidæ	2
23. Caprimulgidæ	3	50. Ciconiidæ	1
24. Phalaropodidæ	3	51. Plataleidæ	1
25. Colymbidæ	3	52. Strepsilidæ	1
26. Saxicolidæ	2	53. Ploteidæ	1
27. Sittidæ	2	Total number of species and races,	352

The number of Species belonging to each Family which breed in the state are as follows:

Mniotiltidæ	25 species	Cuculidæ	2 species
Fringillidæ	23 "	Cathartidæ	2 "
Falconidæ	17 "	Columbidæ	2 "
Anatidæ	15 "	Recurvirostridæ	2 "
Ardeidæ	9 "	Gruidæ	2 "
Scolopacidæ	9 "	Podicipitidæ	2 "
Icteridæ	9 "	Saxicolidæ	1 "
Rallidae	8 "	Sylviidæ	1 "
Turdidæ	7 "	Laniidæ	1 "
Tyrannidæ	7 "	Ampelidæ	1 "
Picidæ	7 "	Alaudidæ	1 "
Strigidæ	7 "	Trochilidæ	1 "
Hirundinidæ	6 "	Cypselidæ	1 "
Vireonidæ	6 "	Alcedinidæ	1 "
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Laridæ	4 "	Perdicidæ	2 "
Paridæ	3 "	Ciconiidæ	1 "
Corvidæ	3 "	Phalaropodidæ	1 "
Tetraonidæ	3 "	Phalacrocoracidæ	1 "
Caprimulgidæ	3 "	Ploteidæ	1 "
Sittidæ	2 "	Colymbidæ	1 "
Laniidæ	2 "		
Tanagridæ	2 "	Total,	213 species

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1. Le Baron, Dr. Wm.—Observations upon some of the birds of Illinois most interesting to the agriculturist. <*Trans. Ill. State Agric. Soc.*, I., 1853, p. 559–65. [A general notice of the common birds of the state, of considerable popular and economic interest.]

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1873.

11. Ridgway, Robert.—The Prairie Birds of Southern Illinois. <*Am. Nat.*, VII., April, 1873, pp. 197–203. [Based on observations made on Fox Prairie, Richland county, in June and August, 1871.]

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"GENERAL SUMMARY."

["Found irrespective of season,	77
Found only in summer,	92
Found only in winter,	47
Found only in spring and fall,	72
Total number of species,	288
Number of species breeding, about	155
Number of species wintering, about	155"]

14. Coues, E.—Birds of Illinois. <*Field and Stream* (*Chicago*), May 2, 1874. [A review of Ridgway's "Catalogue of the Birds ascertained to occur in Illinois," in *Ann. Lyc. N. Y.*, January, 1874, pp. 364–94.]

1876.

15. Nelson, E. W.—Additions to the Avi-fauna of Illinois, with notes on other species of Illinois birds. <*Bull. Nutt. Orn. Club*, I., No. 2, July, 1876, pp. 39–44. [The species added are, *Myiadestes townsendi*, Waukegan, December 16, 1876; *Coturniculus lecontei*, Riverdale, May 13, 1875; *Ammodromus caudacutus* var. *nelsoni*, Calumet Lake, &c., June, September, November; "*Chordeiles popetue* var. *henryi*," Waukegan, July, 1875; *Buteo borealis* var. *calurus*, near Chicago, April, 1873; *Ardea rufa*, near Cairo, August, 1875.]

16. Nelson, E. W.—Notes upon birds observed in Southern Illinois, between July 17, and September 4, 1875. <*Bull. Essex Inst.*, IX., 1876, pp. 32–65. [Includes lists of the species observed at the following localities: *Mt. Carmel and vicinity*, July 17—September 4 (pp. 32–46; 113 species); *Fox Prairie, Richland county*, (pp. 47–50; 64 species); *Cairo and vicinity*, August 17–31 (pp. 50–61; 79 species); *vicinity of Anna, Union county* (pp. 61–4; 83 species). Total number of species observed at the four localities, 133.]

17. Nelson, E. W.—Birds of Northeastern Illinois. <*Bull. Essex Inst.*, VIII., December, 1876, pp. 90–155. [316 species and 12 additional "races;"

180 species breed (?); 24 occur in summer, but are not known to breed; 69 occur only during the migrations; 76 are winter visitants and residents. A list is given of 16 species "not given in the preceding list," but which are known to occur in Illinois—making a total of 332 species known to occur in the state, exclusive of geographical races.]

1877.

18. Jones, W. L.—Arrivals of birds [at Lebanon, Illinois.] <*Field and Forest*, III., No. 1, July, 1877, pp. 17–18.

19. Coale, H. K.—Junco oregonus in Illinois. <*Bull. Nutt. Orn. Club*, II., July, 1877, p. 82. [Near Chicago, October 14, 1875; one specimen.]

20. "W. B." (William Brewster.)—Nelson's "Birds of Northeastern Illinois." <*Bull. Nutt. Orn. Club*, II., July, 1877, pp. 68–9. [Synopsis of paper in Bull. Essex Inst.]

21. Coale, Henry K.—MacCown's Longspur in Illinois. <*Bull. Nutt. Orn. Club*, April, 1877, p. 52. [Champaign, Ill., January 15; 3 specimens.]

22. J. A. A. (J. A. Allen.)—Birds of Southern Illinois. <*Bull. Nutt. Orn. Club*, January, 1878, p. 36. [Review of Nelson's Catalogue (No. 16).]

1878.

23. Ridgway, Robert.—Notes on Birds observed at Mt. Carmel, Southern Illinois, in the spring of 1878. <*Bull. Nutt. Orn. Club*, October, 1878, pp. 162–166. [Twenty-five species mentioned, of which two, *Helinaia swainsoni* (?) and *Ibis alba* are new to the fauna of the state.]

1879.

24. Ridgway, Robert.—On a new species of *Peucæa* from Southern Illinois and central Texas. <*Bull. Nutt. Orn. Club*, October, 1879, pp. 218–22. [*P. illinoënsis*.]

1880.

25. Ridgway, Robert.—The Northern Waxwing (*Ampelis garrulus*) in Southern Illinois. <*Bull. Nutt. Orn. Club*, April, 1880, p. 118. [Pulaski county, December 18, 1879; S. A. Forbes.]

26. Widmann, Otto.—Notes on Birds of St. Louis, Mo. <*Bull. Nutt. Orn. Club*, July, 1880, p. 191. [Relates in great part to birds of Illinois, immediately opposite St. Louis.]

Catalogue of the Birds of Illinois.

[NOTE.—The nomenclature of this list accords with that of the new catalogue of North American birds soon to be published by the Smithsonian Institution. The asterisk prefixed to a number indicates that the species is known to breed in the state of Illinois.]

Order PASSERES.

(*Oscines.*)

Family TURDIDÆ.—Thrushes.

Genus HYLOCICHLA, Baird.

*1. *H. mustelina* (Gmel.) Baird. Wood Thrush. Summer sojourner; abundant.

*2. *H. fuscescens* (Steph.) Baird. Wilson's Thrush. Transient southward; summer sojourner in northern portion.

3. *H. aliciæ*, Baird. Gray-cheeked Thrush. Transient.

*4. *H. ustulata swainsoni* (Caban.) Ridgw. Olive-backed Thrush. Transient, but a few breeding in extreme northern portion.

5. *H. unalascæ pallasi* (Caban.) Ridgw. Hermit Thrush. Transient, but sometimes wintering in southern counties.

Genus MERULA, Leach.

*6. *M. migratoria* (Linn.) Sw. & Rich. American Robin. Resident southward, mainly summer sojourner northward.

Genus MIMUS, Boie.

*7. *M. polyglottus* (Linn.) Boie. Mockingbird. Entire state, but very local, even in southern portion, where resident.

Genus GALEOSCOPTES, Cabanis.

*8 *G. carolinensis* (Linn.) Caban. Catbird. Summer sojourner; occasionally wintering southward.

Genus HARPORHYNCHUS, Cabanis.

*9 *H. rufus* (Linn.) Caban. Brown Thrasher. Summer sojourner; sometimes wintering in southern counties.

Family SAXICOLIDÆ.—Stonechats and Bluebirds.

Genus Sialia, Swainson.

*10. *Sialia sialis* (Linn.) Haldem. Bluebird. Resident and generally distributed; less numerous, and sometimes absent, in winter.

11. *S. arctica*, Swains. Rocky Mountain Bluebird. Accidental visitor. (East side of Mississippi river, opposite Dubuque, Iowa; *fide* E. W. Nelson, Bull. Essex Inst., VIII., 1876, p. 95.)

Family PTILOGONATIDÆ.—Fly-catching Thrushes.

Genus Myiadestes, Swainson.

12. *M. townsendi* (Aud.) Caban. Townsend's Solitaire. Accidental visitor. (Waukegan, December 16, 1875; *cf.* Nelson, Pr. Essex Inst., VIII., 1876, p. 94.)

Family SYLVIIDÆ.—True Warblers.

Genus Polioptila, Sclater.

*13. *P. cœrulea* (Linn.) Scl. Blue-gray Gnatcatcher. Summer sojourner; abundant, southward.

Genus Regulus, Cuvier.

14. *R. calendula* (Linn.) Licht. Ruby-crowned Kinglet. Transient; winter sojourner southward.

15. *R. satrapa*, Licht. Golden-crowned Kinglet. Transient northward, winter sojourner southward.

Family PARIDÆ.—Titmice or Chickadees.

Genus Lophophanes, Kaup.

*16. *L. bicolor* (Linn.) Bp. Tufted Titmouse. Resident; rare northward (where said by Nelson to occur only during fall and winter), but in some southern counties perhaps the most abundant bird.

Genus Parus, Linn.

*17. *P. atricapillus*, Linn. Black-capped Chickadee. Northern portion; resident, but not numerous in winter.

*18. *P. carolinensis*, Aud. Carolina Chickadee. Whole state, but rare northward, where found only in summer (?); southward the only species, except perhaps in winter; abundant, and resident.

19. *P. hudsonicus*, Forst. Hudson's Bay Chickadee. Very rare winter visitant to extreme northern portion. (Rock Island, *fide* Nelson, Bull. Essex Inst., VII., December, 1876, p. 95.)

Family SITTIDÆ.—Nuthatches.

Genus Sitta, Linnæus.

*20. *S. carolinensis*, Linn. White-bellied Nuthatch. Resident.

*21. *S. canadensis*, Linn. Red-bellied Nuthatch. Winter sojourner southward; breeds sparingly in extreme northern portion (Nelson).

Family CERTHIIDÆ.—Creepers.

Genus Certhia, Linnæus.

22. *C. familiaris rufa* (Bartr.) Ridgw. American Brown Creeper. Chiefly transient; winter sojourner southward; possibly breeding northward.

Family TROGLODYTIDÆ.—Wrens.

Genus Thryothorus, Vieillot.

*23. *T. ludovicianus* (Gm.) Bp. Great Carolina Wren. Resident and abundant southward; "rare summer visitant" northward (Nelson).

Genus Thryomanes, Sclater.

*24. *T. bewicki* (Aud.) Baird. Bewick's Wren. In southern counties abundant and resident, being the common, and in many localities the only, "house wren." More rare, and merely summer resident, northward.

Genus Troglodytes, Vieillot.

*25. *T. aëdon*, Vieill. House Wren. Northern and central portions. Apparently entirely absent in many localities southward, where replaced by Bewick's Wren.

25*a*. *T. aëdon parkmanni* (Aud.) Coues. Parkmann's Wren. [Several specimens, from Hyde Park, in the collection of Mr. H. K. Coale, of Chicago, appear to be indistinguishable from typical examples of this western race.]

Genus Anorthura, Rennie.

26. *A. troglodytes hyemalis* (Vieill.) Coues. Winter Wren. Winter sojourner.

Genus Telmatodytes, Cabanis.

*27. *T. palustris* (Wils.) Baird. Long-billed Marsh Wren. Resident (occasionally, at least) southward; summer sojourner northward.

Genus Cistothorus, Cabanis.

*28. *C. stellaris* (Licht.) Caban. Short-billed Marsh Wren. Summer sojourner northward; resident in southern counties. Frequents chiefly the prairie sloughs, but nearly everywhere much rarer than the preceding.

Family MOTACILLIDÆ.—Wagtails and Titlarks.

Genus Anthus, Bechstein.

29. *A. ludovicianus* (Gmel.) Licht. American Titlark. Transient visitor; sometimes winter sojourner southward.

Family MNIOTILTIDÆ.—American Warblers.

Genus Mniotilta, Vieillot.

*30. *M. varia* (Linn.) Vieill. Black and White Creeper. Summer sojourner.

Genus Protonotaria, Baird.

*31. *P. citrea* (Bodd.) Baird. Prothonotary Warbler. Summer sojourner. Abundant in southern counties; rare northward. Found chiefly in wooded swamps or the border of ponds in wooded bottoms.

Genus Helonæa, Audubon.

*32. *H. swainsoni*, Aud. Swainson's Warbler. Believed to be a rather rare summer sojourner in cypress swamps of the extreme southern part of the state. (See Bull. Nutt. Orn. Club, October 1878, p. 163.)

Genus Helminthotherus, Rafinesque.

*33. *H. vermivorus* (Gm.) Salv. & Godm. Worm-eating Warbler. Summer sojourner. Rare northward, but common in southern counties.

Genus Helminthophaga, Cabanis.

*34. *H. pinus* (Linn.) Baird. Blue-winged Yellow Warbler. Summer sojourner, and abundant (locally) in southern portion; not yet recorded from northern portion of the state.

*35. *H. chrysoptera* (Linn.) Baird. Golden-winged Warbler. Chiefly transient, but a rare summer sojourner in semi-prairie districts of central and northern portions of the state, where it breeds sparingly.

*36. *H. ruficapilla* (Wilson) Baird. Nashville Warbler. Summer sojourner northward; transient southward.

37. *H. celata* (Say.) Baird. Orange-crowned Warbler. Transient; common some seasons.

38. *H. peregrina* (Wilson) Baird. Tennessee Warbler. Transient.

Genus Parula, Bonaparte.

*39. *P. americana* (Linn.) Bp. Blue Yellow-backed Warbler. Summer sojourner; breeds throughout the state.

Genus Perissoglossa, Baird.

40. *P. tigrina* (Gmel.) Baird. Cape May Warbler. Transient.

Genus Dendrœca, Gray.

*41. *D. æstiva* (Gmel.) Baird. Summer Yellow Bird. Summer sojourner. The most familiar and generally dispersed member of the entire family. Familiarly known, in many sections, as the "Wild Canary."

42. *D. cærulescens* (Linn.) Baird. Black-throated Blue Warbler. Transient.

43. *D. coronata* (Linn.) Gray. Yellow-rump Warbler. Winter sojourner southward; transient northward.

44. *D. maculosa* (Gmel.) Baird. Black and Yellow Warbler. Transient.

*45. *D. cærulea* (Wilson) Baird. Cerulean Warbler. Summer sojourner; rare northward, but very abundant southward, where it is by far the most numerous of the species which remain to breed; inhabits the woods of tall trees, chiefly in bottom-lands, and therefore scarcely known except to the collector.

*46. *D. pennsylvanica* (Linn.) Baird. Chestnut-sided Warbler. Summer sojourner in northern and central portions; transient in southern counties.

47. *D. castanea* (Wils.) Baird. Bay-breasted Warbler. Transient.

2 48. *D. striata* (Forst.) Baird. Black-poll Warbler. Transient.

2 49. *D. blackburniæ* (Gmel.) Baird. Blackburnian Warbler. Transient.

*50. *D. dominica albilora*, Baird. White-browed Yellow-throated Warbler. Summer sojourner; abundant, locally, southward, where frequenting chiefly the banks of streams in heavily wooded districts.

*51. *D. virens* (Gmel.) Baird. Black-throated Green Warbler. Transient, a few breeding in extreme northern portion (*fide* Nelson).

*52. *D. pinus* (Wils.) Baird. Creeping Pine Warbler. Summer sojourner; in the southern counties breeds in woods of deciduous trees, and occasionally winters.

53. *D. palmarum* (Gmel.) Baird. Red-poll Warbler. Transient. Sometimes wintering southward.

*54. *D. discolor* (Vieill.) Baird. Prairie Warbler. Summer sojourner. One of the least common species, frequenting chiefly the oak "barrens," or other localities covered with a stunted growth.

Genus Siurus, Swainson.

1 *55. *S. aurocapillus* (Linn.) Swains. Golden-crown Thrush. Summer sojourner.

*56. *S. nævius* (Bodd.) Coues. Small-billed Water Thrush; "Water Wagtail." Transient; sometimes wintering in southern counties, and breeding sparingly in extreme northern counties (*fide* Nelson.)

*57. *S. motacilla* (Vieill.) Coues. Large-billed Water Thrush; "Water Wagtail." Summer sojourner; abundant southward, rare northward.

Genus Oporornis, Baird.

58. *O. agilis* (Wilson) Baird. Connecticut Warbler. Transient.

*59. *O. formosa* (Wilson) Baird. Kentucky Warbler. Summer sojourner; very abundant southward.

Genus Geothlypis, Cabanis.

*60. *G. philadelphia* (Wilson) Baird. Mourning Warbler. Chiefly transient, but a rare summer sojourner in certain localities, even south of the parallel of 39°. Commonest in migrations, however, and breeding very sparingly.

2 *61. *G. trichas* (Linn.) Caban. Maryland Yellow-throat. Summer sojourner. An abundant, familiar, and generally diffused species, partial to thickets and brier-patches.

Genus Icteria, Vieillot.

2 *62. *I. virens* (Linn.) Baird. Yellow-breasted Chat. Summer sojourner; rare northward. Usually a companion of the preceding, and distinguished for oddity and variety of its notes; hence, sometimes called "Yellow Mockingbird."

Genus Myiodioctes, Audubon.

*63. *M. mitratus* (Gmel.) Aud. Hooded Warbler. Summer sojourner; rare northward.

64. *M. pusillus* (Wilson) Bp. Black-capped Yellow Warbler. Transient.

*65. *M. canadensis* (Linn.) Aud. Canadian Fly-catching Warbler. Transient, except in extreme northern portion, where breeding.

Genus Setophaga, Swainson.

*66. *S. ruticilla* (Linn.) Sw. American Redstart. Summer sojourner; abundant and generally distributed. Easily recognized by its fan-shaped tail of black and red or yellow, in large patches; the male distinguished for his pretty plumage of black and orange-red.

Family VIREONIDÆ.—Vireos or Greenlets.

Genus Vireosylvia, Bonaparte.

*67. *V. olivacea* (Linn.) Bp. Red-eyed Vireo. Summer sojourner.

*68. *V. philadelphica*, Cassin. Philadelphia Vireo. Transient; a few breeding in the extreme northern part of the state. A not uncommon, but not a well-known species, greatly resembling the succeeding, but distinguished by the absence of a spurious primary, and by the decidedly sulphur-yellow tinge of the throat and breast.

*69. *V. gilva* (Vieill.) Cass. Warbling Vireo. Summer sojourner.

Genus Lanivireo, Baird.

*70. *L. flavifrons* (Vieill.) Baird. Yellow-throated Vireo. Summer sojourner.

71. *L. solitarius* (Vieill.) Baird. Solitary Vireo. Transient; possibly breeding northward.

Genus Vireo, Vieillot.

*72. *V. noveboracensis* (Gmel.) Bp. White-eyed Vireo. Summer sojourner. A denizen of hazel-patches and open thickets; distinguished for its odd notes.

*73. *V. bellii*, Aud. Bell's Vireo. Summer sojourner. Much like the last in habits and notes, but chiefly confined to the prairie districts, and resembling a miniature *Vireosylvia gilva* in colors.

Family LANIIDÆ.—Shrikes.

Genus Lanius, Linnæus.

74. *L. borealis*, Vieill. Great Northern Shrike. Irregular winter visitant; possibly breeding sparingly in northern counties.

*75. *L. ludovicianus*, Linn. Loggerhead Shrike. Resident. In many localities known as the "Mockingbird," from the great similarity in its general appearance to *Mimus polyglottus*. Frequents much the same localities as the latter.

*75*a*. *L. ludovicianus excubitorides* (Swains.) Coues. White-rumped Shrike. A mere variety of the preceding, having lighter colors, with the upper tail-coverts approaching white in color. Found with the preceding, and perhaps the prevailing form on the prairies.

Family AMPELIDÆ.—Wax-wings.

Genus Ampelis, Linnæus.

76. *A. garrulus*, Linn. Northern Wax-wing. Winter visitant chiefly to extreme northern counties; of irregular occurrence, even in northern portions; merely casual southward.

*77. *A. cedrorum*, Vieill. Cedar Wax-wing. Resident, except southward, where chiefly winter sojourner.

Family HIRUNDINIDÆ.—Swallows.

Genus Progne, Boie.

*78. *P. subis* (Linn.) Baird. Purple Martin. Summer sojourner.

Genus Petrochelidon, Cabanis.

*79. *P. lunifrons* (Say.) Lawr. Cliff Swallow. Summer sojourner. Much like the barn swallow in general appearance and habits, but distinguished by its square tail and by its curious gourd-shaped nests attached to the *outside* of buildings. Commonly called "Mud Swallow," or "Square-tailed Eave Swallow."

Genus Hirundo, Linnæus.

*80. *H. erythrogastra*, Bodd. Barn Swallow. Summer sojourner.

Genus Tachycineta, Cabanis.

*81. *T. bicolor* (Vieill.) Caban. White-bellied Swallow. Summer sojourner; usually breeding in holes of trees.

Genus Cotile, Boie.

*82. *C. riparia* (Linn.) Boie. Bank Swallow—"Sand Martin." Summer sojourner; breeding in holes in banks of streams or railroad cuts. Distinguished from the next by its white throat and dark band across the breast.

Genus Stelgidopteryx, Baird.

*83. *S. serripennis* (Aud.) Baird. Rough-winged Swallow—"Sand Martin." Summer sojourner. A companion of the true Bank Swallow, and of very similar appearance, but distinguished by its uniform mouse-colored throat and breast. Often nests about bridges, or even old buildings; but usually in banks, like the *Cotile riparia.*

Family TANAGRIDÆ.—Tanagers.

Genus Pyranga, Vieillot.

*84. *P. rubra* (Linn.) Vieill. Scarlet Tanager. Summer sojourner. One of our most brilliantly colored birds, known usually as the "Black-winged Redbird."

*85. *P. æstiva* (Linn.) Vieill. Summer Redbird. Summer sojourner; abundant southward, but rare in extreme north of the state. Very similar in habits, manners and notes to the preceding, and by many persons erroneously looked upon as a variety or particular stage of plumage of the same species; partial to open, upland woods. A fine songster, the song resembling that of the robin, but more sprightly and continued.

Family FRINGILLIDÆ.—Finches, Sparrows, and Buntings.

Genus Hesperiphona, Bonaparte.

86. *H. vespertina* (Cooper) Bp. Evening Grosbeak. Winter visitant to extreme northern counties.

Genus Pinicola, Vieillot.

87. *P. enucleator* (Linn.) Vieill. Pine Grosbeak. Irregular winter visitant, chiefly to extreme northern portions.

Genus Carpodacus, Kaup.

*88. *C. purpureus* (Gmel.) Baird. Purple Finch. Winter sojourner southward; breeds sparingly in northern counties.

Genus Loxia, Linnæus.

89. *L. curvirostra americana* (Wilson) Coues. American Red Crossbill. Winter visitant, of irregular occurrence southward.

90. *L. leucoptera*, Gmel. American White-winged Crossbill. Winter visitant; occurring throughout the state, but, like the last, appearing very irregularly in the southern portion.

Genus Ægiothus, Cabanis.

91. *Æ. canescens exilipes* (Coues) Ridgw. White-rumped Redpoll. Winter visitant to northern counties.

92. *Æ. linaria* (Linn.) Caban. Common Redpoll. Winter visitant; rare or occasional southward, common and of regular occurrence in the north.

Genus Astragalinus, Cabanis.

// *93. *A. tristis* (Linn.) Cab. American Goldfinch. Resident. An abundant species, familiarly known as the "Lettuce-bird," "Garden-bird," "Hemp-bird," &c.

Genus Chrysomitris, Boie.

94. *C. pinus* (Wilson) Bp. Pine Goldfinch. Transient, and occasional winter sojourner southward. Frequently a companion of the Purple Finch, feeding upon the tender buds of trees in early spring.

Genus Plectrophanes, Meyer.

95. *P. nivalis* (Linn.) Meyer. Snow Bunting. An abundant winter visitant in northern counties, but very rare in the southern portion of the state. Commonly known as the "White Snow-bird," and "Snowflake."

Genus Centrophanes, Kaup.

96. *C. lapponicus* (Linn.) Caban. Lapland Longspur. Winter visitant; sometimes abundant, even in the extreme southern portions; occasionally seen in full spring plumage in northern counties.

97. *C. pictus* (Swains.) Caban. Painted Longspur. A winter visitant, like the last, but chiefly confined to the prairie districts, where sometimes extremely abundant.

Genus Rhynchophanes, Baird.

98. *R. maccowni* (Lawr.) Baird. McCown's Longspur. Casual winter visitant. (Champaign, January, 1877; three specimens. H. K. Coale, Bull. Nutt. Orn. Club, April, 1877, p. 52.)

Genus Passerculus, Bonaparte.

*99. *P. sandwichensis savanna* (Wils.) Ridgw. Savannah Sparrow. Summer sojourner, wintering southward.

Genus Poœcetes, Baird.

*100. *P. gramineus* (Gmel.) Baird. Bay-shouldered Bunting. Summer sojourner; resident southward, where, however, it breeds sparingly. An inhabitant of fields and meadows, or open prairies. This, with other species of similar habits, as the Savannah and Yellow-winged Sparrows, are familiarly known as "Grass-birds," or "Ground-birds."

Genus Coturniculus, Bonaparte.

2 *101. *C. passerinus* (Wilson) Bp. Yellow-winged Bunting. Summer sojourner; occasionally a few wintering southward. This is the commonest of the "Grass-birds," frequenting meadows, where well known from its peculiar lisping song which resembles the rasping note of a grasshopper (locust); hence known locally as "Grasshopper-bird" and "Cricket-bird."

*102. *C. henslowi* (Aud.) Bp. Henslow's Bunting. Summer sojourner; in southern counties sometimes wintering. A common species on weedy prairies, with habits much like the preceding, but with a different song (sounding like *pil'-lut*, or *se'-wick*,) which it utters while perched on the summit of a tall weed.

*103. *C. lecontei* (Aud.) Bp. Leconte's Bunting. Chiefly transient, but doubtless breeding in northwestern counties. Inhabits chiefly wet prairies, where it keeps hidden in the rank grass and sedges like the *Ammodromi*. [Taken in Chicago, May 2, 1878, by C. A. White (H. K. Coale, *in epist.*); at Riverdale, Cook county, May 13 and 17, 1875, by E. W. Nelson; and in Hancock county by C. K. Worthen, "both in fall and spring, as well as during summer." (See Bull. Nutt. Orn. Club, January, 1880, p. 32)].

Genus Ammodromus, Swainson.

*104. *A. caudacutus nelsoni*, Allen. Nelson's Sharp-tailed Bunting. A summer resident in northern counties, where it inhabits grassy marshes. It is a recently discovered race, and its distribution is consequently not well made out. It very likely winters in sheltered marshes in the southern portion of the state.

Genus Chondestes, Swainson.

*105. *C. grammica* (Say) Bp. Lark Bunting. Summer sojourner; entire state, but partial to the semi-wooded districts. Easily distinguished from all other terrestrial sparrows (except the Chewink—*Pipilo erythrophthalmus*, which is otherwise very different), by the white-tipped tail; usually seen along roadsides. A sweet and indefatigable singer, surpassing the canary and every native species in continuity and sprightliness of song, through which are interspersed most pleasing trills and varied cadences. Nests indifferently on the

ground or in a small tree, the eggs being singularly handsome, of a crystal-white ground-color, peculiarly marked with irregular lines and spots of black round the larger end.

Genus ZONOTRICHIA, Swainson.

106. *Z. querula* (Nutt.) Gamb. Harris's Sparrow. Casual visitor from the west. [Taken by W. H. Garman, at Normal, McLean county, November 14, 1879, and near Bloomington, in spring of 1877]. (See Bull. Nutt. Orn. Club, January, 1880, p. 30.)

107. *Z. leucophrys* (Forst.) Sw. White-crowned Sparrow. Transient northward; winter sojourner southward.

[*Z. gambeli intermedia*, Ridgw. Western White-crowned Sparrow. Obtained near Racine, Wisconsin, April 20, 1871, by Dr. P. R. Hoy. *Fide* Nelson, p. 107.]

[*Z. coronata* (Pallas) Baird. Golden-crowned Sparrow. A single specimen obtained near Racine, Wisconsin, in April, 1858, by Dr. Hoy. *Fide* Nelson, p. 108.]

*108. *Z. albicollis* (Gmel.) Bp. White-throated Sparrow. Winter sojourner southward. A "rare summer resident" in northern counties (*fide* Nelson, p. 108).

Genus SPIZELLA, Bonaparte.

109. *S. montana* (Forst.) Ridgw. Tree Sparrow. Winter sojourner. An almost constant companion of the preceding.

*110. *S. domestica* (Bartr.) Coues. Chipping Sparrow. Summer sojourner, occasionally wintering southward (?).

*111. *S. pallida* (Swains.) Bp. Clay-colored Sparrow. Summer resident in certain semi-prairie districts westward and northward.

*112. *S. pusilla* (Wilson) Bp. Field Sparrow. Summer sojourner northward; resident southward.

Genus JUNCO, Wagler.

113. *J. hyemalis* (Linn.) Scl. Common Snowbird. Winter sojourner.

114. *J. oregonus* (Towns.) Scl. Oregon Snowbird. Chicago, October 14, 1875; one specimen. [H. K. Coale, Bull. Nutt. Orn. Club, July, 1877, p. 82.]

Genus PEUCÆA, Audubon.

*115. *P. æstivalis illinoensis*, Ridgw. Oak-woods Sparrow. Summer resident in the southern third of the state, but very local; has been obtained only in Wabash and Richland counties, where not discovered until 1871. The typical form of the species has been recorded only from lower South Carolina and Georgia, and adjacent parts of Florida. Inhabits chiefly neglected fields, more or less grown up with weeds or bushes, and surrounded by woods. The favorite perch of the male while singing is an old dead tree, from which, at midday, in the most sultry weather of July and August, he pours forth his simple chant of exceedingly clear and sweet notes; but upon the least alarm dives into the bushes or weeds, and thus easily conceals itself.

Genus Melospiza, Baird.

*116. *M. fasciata* (Gmel.) Scott. Song Sparrow. Summer sojourner northward, but only a winter sojourner in the southern counties, where, with the Swamp, Lincoln's, White-throated, Fox-colored, Tree and Field Sparrows, it congregates in multitudes in the sheltered swamps in the heavily wooded districts.

*117. *M. palustris* (Wils.) Baird. Swamp Sparrow. Abundant summer sojourner northward; equally abundant winter sojourner southward.

*118. *M. lincolni* (Aud.) Baird. Lincoln's Sparrow. Mainly transient; a few breeding in the extreme northern counties (*fide* Nelson), and sometimes wintering, in considerable numbers, in the south.

Genus Passerella, Swainson.

119. *P. iliaca* (Merrem) Sw. Fox-colored Sparrow. Transient northward, but wintering in the south. One of the largest of our Sparrows, resembling a Thrush in its rufous coloring and spotted breast.

Genus Pipilo, Vieillot.

*120. *P. erythrophthalmus* (Linn.) Vieill. Ground Robin. Resident southward; summer sojourner northward. A well-known, familiar species, commonly known as the "Chewink," "Jaree," and "Towhee."

Genus Cardinalis, Bonaparte.

*121. *C. virginianus* (Briss.) Bp. Cardinal Grosbeak. Abundant resident southward; rare summer sojourner in extreme north. Commonly called "Red Bird" or "Crested Red Bird."

Genus Zamelodia, Coues.

*122. *Z. ludoviciana* (Linn.) Coues. Rose-breasted Grosbeak. Summer sojourner northward; transient southward.

Genus Guiraca, Swainson.

*123. *G. cærulea* (Linn) Sw. Blue Grosbeak. Summer sojourner. Apparently confined to the southern portion of the state, where rare and local. Affects the same localities as the Indigo Bird, and seems like an "enlarged edition" of that species, but is at least twice the bulk, while the male has his duller blue plumage relieved by the rufous tips of the wing-coverts.

Genus Passerina, Vieillot.

*124. *P. cyanea* (Linn.) Gray. Indigo Bird. Summer sojourner.

125. *P. ciris* (Linn.) Gray. Nonpareil Bunting. Summer visitant to southern counties. Possibly breeds, and should be diligently looked for. Thus far only one record of its occurrence within the state (Wabash county, near Mt. Carmel, June, 1871). The male is a very conspicuous bird,—bright red below, with blue head and green back; the female, uniform grass-green, paler and more yellowish below.

Genus Spiza, Bonaparte.

*126. *S. americana* (Gmel.) Bp. Black-throated Bunting. Summer sojourner, abundant in most localities; an inhabitant of meadows and prairies;

an indefatiguable songster, whose notes, while lacking melody or sweetness, are, however, not unpleasing, and are variously interpreted as "Dick-cissel," "Judas Iscariot," &c., whence some of its various local names. The male having a yellow breast, adorned with a black shield-shaped spot, and thereby much resembling the Meadow Lark in color, while its haunts are the same, it is not unfrequently known as the "Little Field Lark." Its eggs, of a uniform pale blue, without markings of any kind, very closely resemble those of the common Bluebird *(Sialia sialis.)*

Family ICTERIDÆ.—American Starlings.

Genus Dolichonyx, Swainson.

*127. *D. oryzivorus* (Linn.) Sw. Bob-o-link. Summer sojourner northward; transient southward. The male in spring plumage frequently called "Skunk Blackbird."

Genus Molothrus, Swainson.

*128. *M. ater* (Bodd.) Gray. Cow Blackbird. Resident southward; summer sojourner northward. Sometimes known as "Clod-hopper," from the habit, which it possesses in common with other "blackbirds," of following the ploughman. The only one of our birds which never builds a nest, but habitually deposits its eggs in the nests of other birds.

Genus Xanthocephalus, Bonaparte.

*129. *X. icterocephalus* (Bp.) Baird. Yellow-headed Blackbird. Summer sojourner; occasionally resident southward, confined to the prairie districts.

Genus Agelæus, Vieillot.

9 *130. *A. phœniceus* (Linn.) Vieill. Red-winged Blackbird. Resident southward; summer sojourner northward.

Genus Sturnella, Vieillot.

*131. *S. magna* (Linn.) Sw. Meadow Lark. Resident; universally distributed.

*132. *S. neglecta*, Aud. Western Meadow Lark. Resident. Strictly a prairie bird; closely resembling the preceding in all respects except voice, the notes being all exceedingly different, and the song very far superior.

Genus Icterus, Brisson.

12 *133. *I. galbula* (Linn.) Coues. Baltimore Oriole. Summer sojourner. The most common appellation of this familiar and brilliant species is "Hanging-bird" but it is also known as the "Hang-nest," "Golden Oriole," "Golden Robin," "Fire-bird," &c.

*134. *I. spurius* (Linn.) Bp. Orchard Oriole. Summer sojourner. More abundant south than the preceding.

Genus Scolecophagus, Swainson.

135. *S. ferrugineus* (Gmel.) Sw. Rusty Blackbird. Transient, sometimes wintering southward.

136. *S. cyanocephalus* (Wagler) Caban. Brewer's Blackbird. An occasional straggler from the west.

Genus Quiscalus, Vieillot.

32 *137. *Q. purpureus æneus*, Ridgw. Bronzed Grackle. Resident southward; summer sojourner northward. The common "Blackbird."

Family CORVIDÆ.—Crows and Jays.

Genus Corvus, Linnæus.

*138. *C. corax carnivorus* (Bartr.) Ridgw. American Raven. Resident, but very local.

*139. *C. frugivorus*, Bartr. Common Crow. Resident; abundant, and generally distributed.*

Genus Pica, Cuvier.

140. *P. rustica hudsonica* (Sabine) Baird. Black-billed American Magpie. Of very doubtful occurrence in Illinois, at least at present, but given by Mr. Kennicott as a rare winter visitant to the extreme northern counties.

Genus Cyanocitta, Strickland.

21 *141. *C. cristata* (Linn.) Strickl. Blue Jay. Resident; abundant, and generally distributed. In most localities one of the most familiar of the native birds, quite in contrast to its habits in the eastern states.

Family ALAUDIDÆ.—Larks.

Genus Eremophila, Boie.

*142. *E. alpestris* (Forster) Boie. Horned Lark. Resident entire state, but chiefly the prairie districts.†

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*It is altogether likely that the Fish Crow (*C. ossifragus*, Wilson), will eventually have to be added to the list of Illinois birds. I have several times heard, on the Wabash river, at Mt. Carmel, the notes of a Crow which were identical with those of this species, whose voice is exceedingly different from that of the common kind, being a sort of "cracked" croak, or barking sound; something like we would imagine a common crow with a very bad cold to utter. The species should be sought for along the larger streams in the southern part of the state, since its habitat is strictly littoral and fluviatile, and at the same time essentially southern.

†Mr. Nelson includes the pale form distinguished by the name of *leucolæma*, Coues, in his list (p. 110). This, however, is an error, so far as the specimens upon which the statement was based are concerned, but one for which I am chiefly responsible. A series of specimens was submitted to me for examination, and certain examples, in very pale plumage, I pronounced to be the "var. *leucolæma*." In this I was mistaken, the individuals in question proving to be the true *alpestris*, in much faded summer plumage. Although it is frequently not easy to distinguish the adults of the two forms, there is never any difficulty with the young, that of *leucolæma* being many shades lighter in color, the difference being moreover absolutely constant. I was only made aware of my mistake by the subsequent inspection of young birds said to be the same form which I had previously identified as *leucolæma*; and, neglecting to explain the case in time, am thus responsible in great measure for the statements made by Mr. Nelson in regard to these birds, as cited above.

(Oligomyodæ.)

Family TYRANNIDÆ.—Tyrant Flycatchers.

Genus Tyrannus, Cuvier.

*143. *T. carolinensis* (Linn.) Baird. King Bird. Summer sojourner; commonly known as the Bee Bird or Bee Martin.

Genus Myiarchus, Cabanis.

*144. *M. crinitus* (Linn.) Caban. Great Crested Flycatcher. Summer sojourner; usually a woodland species, but not unfrequently seen in towns, where it sometimes builds in the hollow branches of shade-trees, or even the eaves of buildings.

Genus Sayornis, Bonaparte.

*145. *S. fuscus* (Gmel.) Baird. Pewee. Summer sojourner, often wintering southward.

146. *S. sayi* (Bp.) Baird. Say's Pewee. Casual or accidental in northern part of the state (*fide* Nelson, Bull. Essex. Inst., VIII., 1876, p. 113).

Genus Contopus, Cabanis.

147. *C. borealis* (Sw.) Baird. Olive-sided Flycatcher. Rare, transient; possibly breeds in extreme northern counties.

*148. *C. virens* (Linn.) Caban. Wood Pewee. Summer sojourner.

Genus Empidonax, Cabanis.

149. *E. flaviventris*, Baird. Yellow-bellied Flycatcher. Transient; possibly summer sojourner northward.

*150. *E. acadicus* (Gmel.) Baird. Green-crested Flycatcher. Summer sojourner. More numerous southward than Traill's Flycatcher, but inhabiting the same localities, and difficult to distinguish; nest very different, however, and plumage quite distinct on comparison.

*151. *E. pusillus trailli* (Aud.) Baird. Traill's Flycatcher. Summer sojourner; whole state, but said to be rare northward.

*152. *E. minimus*, Baird. Least Flycatcher. Transient southward; summer sojourner northward.

Order TROCHILI.

Family TROCHILIDÆ.—Humming-birds.

Genus Trochilus, Linnæus.

*153. *T. colubris*, Linn. Ruby-throated Humming-bird. Summer sojourner. *Our only species.*

Order CYPSELI.

Family CYPSELIDÆ.—Swifts.

Genus Chætura, Stephens.

*154. *C. pelasgica* (Linn.) Baird. Chimney Swift. Summer sojourner. Usually known as the "Chimney Swallow."

Order CAPRIMULGI.

Family CAPRIMULGIDÆ.—Goatsuckers.

Genus Antrostomus, Gould.

*155. *A. carolinensis* (Gmel.) Gould. Chuck-will's-widow. Summer sojourner in southern counties. Confounded with the following, but note louder and less hurriedly enunciated; habits the same.

Genus Caprimulgus, Linnæus.

*156. *C. vociferus*, Wils. Whip-poor-will. Summer sojourner.

Genus Chordeiles, Swainson.

*157. *C. popetue* (Vieill.) Baird. Night Hawk. Summer sojourner. Popularly supposed to be the whip-poor-will, but readily distinguishable on sight by the conspicuous white wing-spot, its partially diurnal habits, and other well-marked characteristics.*

Order PICI.

Family PICIDÆ.—Woodpeckers.

Genus Campephilus, Gray.

*158. *C. principalis* (Linn.) Gray. Ivory-billed Woodpecker. A former resident in the extreme southern counties, but now extinct in many districts.

Genus Picus, Linnæus.

*159. *P. villosus*, Linn. Hairy Woodpecker. Resident; commonly known as the "Big Sapsucker," or "Guinea Woodpecker."

*160. *P. pubescens*, Linn. Downy Woodpecker. Resident. The well-known "Little Sapsucker," or "Little Guinea Woodpecker."

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*Mr. Nelson (p. 114) gives "var. *henryi*, Cass.," as occurring and breeding in Cook county. We have, in conjunction with Mr. Nelson, compared the specimens referred to, with typical examples of the western form, and conclude that they are merely somewhat pale examples of the eastern bird, or true *popetue*, as restricted.

Genus Picoides, Lacepede.

161. *P. arcticus* (Sw.) Gray. Black-backed Three-toed Woodpecker. A rare winter visitant to extreme northern counties.

Genus Sphyrapicus, Baird.

162. *S. varius* (Linn.) Baird. Yellow-bellied Woodpecker. Winter sojourner in southern portions; transient northward. Not a conspicuous or well-known species, but, when distinguished, sometimes called the "Red-throated Sapsucker," or, on account of its mournful, whining note, "Squealing Sapsucker."

Genus Hylotomus, Baird.

*163. *H. pileatus* (Linn.) Baird. Pileated Woodpecker. Resident, and in many districts still abundant. Popularly known as the "Log Cock," "Black Woodcock," or, and perhaps most frequently, as simply "Woodcock."

Genus Centurus, Swainson.

*164. *C. carolinus* (Linn.) Bp. Red-bellied Woodpecker. Abundant resident southward; rather rare summer sojourner northward. Its popular names are "Checkered Woodpecker," "Woodchuck," and "Chuck."

Genus Melanerpes, Swainson.

*165. *M. erythrocephalus* (Linn.) Sw. Red-headed Woodpecker. Resident; excessively abundant in heavily wooded bottoms of the southern counties, in winter.

Genus Colaptes, Swainson.

*166. *C. auratus* (Linn.) Sw. Yellow-shafted Flicker. Resident. Has numerous popular names, as "Yellow-hammer" (the most frequent), "Flicker," "High-hole," "Wake-up," "Pigeon Woodpecker," &c.

Order ANISODACTYLÆ.

Family ALCEDINIDÆ.—Kingfishers.

Genus Ceryle, Boie.

*167. *C. alcyon* (Linn.) Boie. Belted Kingfisher. Resident southward; summer sojourner northward.

Order COCCYGES.

Family CUCULIDÆ.—Cuckoos.

Genus Coccyzus, Vieillot.

*168. *C. americanus* (Linn.) Bp. Yellow-billed Cuckoo. Summer sojourner. Commonly known as the "Rain Crow" or "Wood Pigeon."

*169. *C. erythrophthalmus* (Wils.) Baird. Black-billed Cuckoo. Summer sojourner. Popularly confounded with the preceding, but in most localities, especially southward, much less common.

Order PSITTACI.

Family PSITTACIDÆ.—Parrots.

Genus Conurus, Kuhl.

*170. *C. carolinensis* (Linn.) Kuhl. Carolina Parakeet. Formerly abundant, and generally distributed; possibly now extinct in Illinois.

Order STRIGES.

Family STRIGIDÆ.—Owls.

Genus Aluco, Fleming.

*171. *A. flammeus americanus* (Aud.) Ridgw. Barn Owl. Of rare and irregular occurrence. Found at all seasons of the year, but nowhere common.

Genus Asio, Brisson.

*172. *A. americanus* (Steph.) Sharpe. Long-eared Owl. Resident.

*173. *A. accipitrinus* (Pall.) Newton. Short-eared Owl. Chiefly winter sojourner, but breeding in northern counties.

Genus Strix, Linnæus.

*174. *S. nebulosa*, Forst. Barred Owl. Resident. The common "Hoot Owl."

Genus Ulula, Cuvier.

175. *U. cinerea* (Gm.) Bp. Great Gray Owl. Very rare winter visitant to extreme northern counties (Nelson, p. 117).

Genus Nyctale, Brehm.

*176. *N. acadica* (Gmel.) Bp. Saw-whet Owl. Common resident in extreme northern portion; rare winter visitant southward.

Genus Scops, Savigny.

/ *177. *S. asio* (Linn.) Bp. Little Red Owl, or Mottled Owl. Resident. Universally known as the "Screech Owl."

Genus Bubo, Duméril.

*178. *B. virginianus* (Gmel.) Bp. Great Horned Owl. Resident.

178*a*. *B. virginianus subarcticus* (Hoy) Ridgw. Western Horned Owl. Winter visitant to northern portions.

Genus Nyctea, Stephens.

179. *N. scandiaca* (Linn.) Newton. Snowy Owl. Winter visitant; of irregular occurrence, but sometimes common.

Genus Surnia, Duméril.

180. *S. funerea* (Linn.) Sw. & Rich. American Hawk Owl. Winter visitant to extreme northern counties (Kane county, Sept. 1869; Nelson, p. 117).

Order ACCIPITRES.

Family FALCONIDÆ.—Hawks, Falcons, Kites and Eagles.

Genus Hierofalco, Cuvier.

181. *H. mexicanus polyagrus* (Cass.) Ridgw. Prairie Falcon. A straggler from the west.

Genus Falco, Linnæus.

*182. *F. peregrinus nævius* (Gm.) Ridgw. Duck Hawk. Resident, locally.

Genus Æsalon, Kaup.

*183. *Æ. columbarius* (Linn.) Kaup. Pigeon Hawk. Resident, locally; more common in spring and fall.

Genus Tinnunculus, Vieillot.

*184. *T. sparverius* (Linn.) Vieill. American Kestril. Resident; probably the most abundant species of the family, generally known as the "Sparrow Hawk."

*184*a*. *T. sparverius isabellinus* (Sw.) Ridgw. Isabelline Kestril. An adult female in my collection is a very extreme example of this southern race. It was obtained at Mt. Carmel, October 5, 1874. The entire pileum is dark plumbeous, without the least trace of rufous on the crown, while the durky bars on the upper surface are everywhere much wider than the rufous intersperses. I have also a very typical male, the color very dark, with uniform deep plumbeous pileum and unspotted deep vinaceous breast.

Genus Pandion, Savigny.

*185. *P. haliaëtus carolinensis* (Gm.) Ridgw. American Osprey. Resident southward, at least in mild winters; transient northward (according to Nelson, p. 118).

Genus Elanoides, Gray.

*186. *E. forficatus* (Linn.) Ridgw. Swallow-tailed Kite. Summer sojourner; rare northward, but extremely abundant, at times, in the southern counties. Most numerous in August, on the prairies or near water-courses.

Genus Elanus, Savigny.

*187. *E. glaucus* (Bartr.) Coues. White-tailed Kite. Very rare summer sojourner in extreme southern portion.

Genus Ictinia, Vieillot.

*188. *I. subcærulea* (Bartr.) Coues. Mississippi Kite. Summer sojourner; rare northward, but, like the Swallow-tail, very abundant locally, especially in August, in the southern third of the state. Usually seen soaring in company with Turkey Buzzards or the Swallow-tailed Kites, often performing extraordinary and beautiful aërial evolutions.

Genus Circus, Lacépède.

*189. *C. hudsonius* (Linn.) Vieill. Marsh Hawk. Chiefly winter sojourner, but resident northward, and (probably) on southern prairies.

Genus Accipiter, Brisson.

*190. *A. cooperi*, Bp. Cooper's Hawk. Resident. Commonly known as the "Blue Chicken Hawk," "Swift Hawk," "Quail Hawk," &c.

*191. *A. fuscus* (Gmel.) Bp. Sharp-shinned Hawk. Resident.

Genus Astur, Lacépède.

192. *A. atricapillus* (Wils.) Bp. American Goshawk. Winter visitant; rare southward.

Genus Buteo, Cuvier.

*193. *B. borealis* (Gmel.) Vieill. Red-tailed Hawk. Resident. The common "Rabbit Hawk," or "White-breasted Hen Hawk."

193*a*. *B. borealis calurus* (Cass.) Ridgw. Western Red-tailed Hawk. Occasional, or accidental visitant from the west (Cook county, April, 1873; see Nelson, p. 119).

194. *B. harlani*, Aud. Harlan's Hawk; Black Warrior. Taken at Warsaw, Hancock county, in March, 1879, by Mr. C. K. Worthen (see Bull. Nutt. Orn. Club, January, 1880, p. 31).

*195. *B. lineatus* (Gmel.) Jard. Red-shouldered Hawk. Resident. The most abundant species of the genus.

*196. *B. swainsoni*, Bp. Swainson's Hawk. An uncommon and rather local species. Obtained several times within the state, and found breeding in Richland county, by Mr. E. W. Nelson. (See Bull. Essex. Inst., IX., 1877, p. 47.)

*197. *B. pennsylvanicus* (Wils.) Bp. Broad-winged Hawk. Resident. One of the rarer species in most localities.

Genus Asturina, Vieillot.

198. *A. nitida plagiata* (Licht.) Ridgw. Mexican Goshawk. Rare, perhaps accidental, summer visitant to southern portion. (Fox Prairie, Richland county, August, 1871; one specimen. (See *American Naturalist*, July, 1872, p. 430, and April, 1873, p. 203.)

Genus Archibuteo, Brehm.

199. *A. lagopus sancti-johannis* (Gm.) Ridgw. Rough-legged Hawk. Winter sojourner.

200. *A. ferrugineus* (Licht.) Gray. Ferruginous Rough-legged Hawk. Recently added to the fauna of the state, by Dr. Coues, who observed specimens near Rock Island, in October, 1876. (See Bull. Nutt. Orn. Club, II., p. 26.)

Genus Aquila, Brisson.

*201. *A. chrysaëtos canadensis* (Linn.) Ridgw. Golden Eagle. Chiefly winter visitant, but a few still breeding in rocky, unfrequented districts (see Nelson, p. 120).

Genus Haliæetus, Savigny.

*202. *H. leucocephalus* (Linn.) Savig. Bald Eagle. Resident, but most abundant in winter. The young, which in their second year exceed the adults in spread of wing and tail, as well as in *apparent* bulk, while their plumage is exceedingly different, are commonly called "Gray Eagles." Younger individuals, or those in the first plumage, are distinguished as "Black Eagles," a name also applied to the Golden Eagle *(Aquila chrysaëtus canadensis)*. Many persons, even experienced hunters, are unaware of the identity of these black and gray Eagles with those having the head and tail white. The "Washington Eagle," or "Bird of Washington," of Audubon, was founded on a large-sized immature female of this common species.

Order SARCORHAMPHI.

Family CATHARTIDÆ.—American Vultures.

Genus Cathartes, Illiger.

*203. *C. aura* (Linn.) Illig. Turkey Buzzard. Resident and very abundant in southern half of the state; a rare summer sojourner northward..

Genus Catharista, Vieillot.

*204. *C. atrata* (Wils.) Less. Black Vulture. Rare resident in southern counties. The common "Carrion Crow" of the southern states.

Order COLUMBÆ.

Family COLUMBIDÆ.—Pigeons or Doves.

Genus Ectopistes, Swainson.

*205. *E. migratoria* (Linn.) Sw. Irregular resident.

Genus Zenaidura, Bonaparte.

*206. *Z. carolinensis* (Linn.) Bp. Mourning Dove. Resident southward; summer sojourner northward.

Order GALLINÆ.

(Gallinæ alectoropodes.)

Family MELEAGRIDÆ.—Turkeys.

Genus Meleagris, Linnæus.

*207. *M. gallopavo americana* (Bartr.) Coues. Wild Turkey.* Resident.

Family TETRAONIDÆ.—Grouse.

Genus Bonasa, Stephens.

*208. *B. umbellus* (Linn.) Steph. Ruffled Grouse. Resident.†

Genus Cupidonia, Reichenbach.

*209. *C. cupido* (Linn.) Baird. Pinnated Grouse. Resident. The common "Prairie Chicken" or "Prairie Hen."

Genus Pediœcetes, Baird.

*210. *P. phasianellus columbianus* (Ord.) Coues. Sharp-tailed Grouse. Resident; northern prairies only. Said to be very scarce, and less numerous than formerly. Should be looked for carefully. Has the same habits as the common "Prairie Chicken," and is quite similar in appearance, but may be distinguished by the form of the markings on the lower parts, which are V-shaped, instead of running straight across, bar-like, by the absence of the elongated feathers on the sides of the neck, and other differences.

Genus Lagopus, Vieillot.

211. *L. albus* (Gmel.) Aud. Willow Ptarmigan. Formerly a rare winter visitant to extreme northern counties, according to Kennicott. Not recorded

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*That the common wild turkey of the Eastern United States is identical specifically with the domesticated bird, there is no reason to doubt, since the able and exhaustive discussion of the matter by Judge Caton, in his recent treatise in the *American Naturalist* for June, 1877, pp. 321–330. In view, however, of the perfect correspondence in plumage between the barnyard turkey, in its perfect normal plumage (we of course except the albinescent, erythrismal, or rufous and cream-colored, and melanistic varieties,) with the wild bird of eastern Mexico and the southern Rocky Mountains of the United States, it seems most reasonable to regard the latter as the original of the domesticated race—a supposition greatly strengthened by historical circumstances, which unavoidably lead to the conclusion that the bird was originally introduced into Europe by the Spaniards, after the conquest of Mexico, and afterward "transplanted" to the United States by the early European settlers. As to the matter of nomenclature, the whole question depends upon whether Linnæus based his diagnosis on the domesticated turkey or the wild North American bird. In the event of his *M. gallopavo* being meant for the former, the bird under consideration must be called *americana*, after Bartram; but if Linnæus had the wild bird of North America in view, then the latter name becomes a synonym of *gallopavo*, while the Mexican, and with it the domesticated bird, where unmixed with wild stock, must be called *mexicana*, Gould.

†As is apparently the case throughout the Southern States, wherever this species is found, all tne Ruffed Grouse of Southern Illinois have, so far as I have seen, rufous tails. In the northern portion of the state examples with gray tails are common, as is the case in New England and the Middle States generally, especially in the mountain districts. This prevalence of the rufous-tailed type seems strictly parallel to the case of the little "Screech Owl" (*Scops asio*), nearly all the individuals of which are of the bright rufous, or foxy-red phase in Southern Illinois, and is perhaps due to the same climatic causes.

by subsequent observers, and perhaps not now entering the state (see Nelson, p. 122).

Family PERDICIDÆ.—Partridges and Quails.

Genus Ortyx, Stephens.

*212. *O. virginiana* (Linn.) Bp. Virginia Quail, or Partridge.* Resident.

*212*a*. *O. virginiana floridana*, Coues. Southern Quail. Restricted to the heavily wooded bottom-lands of the southern portion of the state (see Nelson, Bull. Essex. Inst., IX., 1877, p. 43).†

Order HERODIONES.

Family CICONIIDÆ.—Storks and Wood Ibises.

Genus Tantalus, Linnæus.

*213. *T. loculator*, Linn. Wood Ibis. Summer sojourner in extreme south of the state, and an irregular summer visitant to northern portion.

Family IBIDIDÆ.—Ibises.

Genus Eudocimus, Wagler.

214. *E. albus* (Linn.) Wagl. White Ibis. A summer visitant as far north as Mt. Carmel, where occasionally seen in small flocks.

Genus Plegadis, Kaup.

215. *P. falcinellus* (Linn.) Kaup. Glossy Ibis. Summer visitant, of irregular occurrence.

Family PLATALEIDÆ.—Spoonbills.

Genus Ajaja, Reichenbach.

216. *A. rosea* (Briss.) Ridgw. Rosy Spoonbill. Although this species, like the Parakeet and Ivory-billed Woodpecker, may not now be found within the state, except, perhaps, as a rare or accidental summer visitant, I am informed by Mr. A. Wolle, a trustworthy dealer, of Baltimore, Maryland, that

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*It is, of course, quite unnecessary to discuss at length the question of whether this well-known bird is a "quail" or a "partridge." Suffice it to say that these two terms, in their proper sense, apply strictly to two very distinct groups of species belonging to this family, *and peculiar to the Old World*. Our bird is exactly half way between the true Partridge and Quail of Europe, in size and many of its other characteristics; and, though it is *neither*, in the strict sense of the word, it may as properly be termed one as the other.

†Specimens obtained at Mt. Carmel, by Mr. Nelson, as well as those in my own collection, from the same locality, agree strictly with many Florida examples in their small size, very dark colors, and massive bills. There are, however, slight differences in color from the extreme developement of the race, as represented in specimens from Southern Florida. Thus, while the black of the jugulum is equally extended, the black bars of the lower parts are rather less heavy, and less regularly transverse. The most obvious difference, however, consists in the coloration of the dorsal surface, where the prevailing tint is bright rusty red, varied by large black blotches, in the Southern-Illinois birds, while in the Floridan examples the upper parts have a decided dull olive-grayish cast, tinged with rusty, and broken by smaller, more numerous, and more transverse markings. The massiveness of the bill, however, by some supposed to be specially characteristic of peninsular birds, is equally shared by Illinois specimens, one example, in my collection from Mt. Carmel, having this member more bulky than in any Florida specimen which I have ever seen!

he collected specimens some twenty years ago in the Mississippi bottom, a few miles below St. Louis, where it was not uncommon about the large ponds. It may yet be found in suitable localities, and should be carefully looked for in the southern marshes (see Bull. Nutt. Orn. Club, Jan. 1880, p. 31).

Family ARDEIDÆ.—Herons.

Genus Ardea, Linnæus.

217. *A. occidentalis*, Aud. Great White Heron; Würdemann's Heron.* A rare summer visitant to the southern part of the state (Mt. Carmel, September, 1876).

*218. *A. herodias*, Linn. Great Blue Heron. Summer sojourner. A few remain in mild winters.

Genus Herodias, Boie.

*219. *H. alba egretta* (Gmel.) Ridgw. American Egret. Chiefly a summer visitant, but breeding in the southern counties. Popularly known as the "White Crane." Sometimes abundant late in summer.

Genus Garzetta, Kaup.

*220. *G. candidissima* (Gm.) Bp. Snowy Heron. Chiefly a summer visitant, but breeding southward.

Genus Dichromanassa, Ridgway.

221. *D. rufa* (Bodd.) Ridgw. Reddish Egret. A summer visitant (possibly breeding) in the extreme southern portion of the state (see Nelson, Bull Essex. Inst., IX., 1877, p. 60).

Genus Florida, Baird.

*222. *F. cærulea* (Linn.) Baird. Little Blue Heron. Summer sojourner in southern part of the state, where sometimes exceedingly abundant in latter part of summer.

Genus Butorides, Blyth.

/ *223. *B. virescens* (Linn.) Bp. Green Heron. Summer sojourner. A well-known, widely distributed species, enjoying the inelegant but expressive sobriquet of "Schytepoke," in addition to its other names of "Poke," "Fly-up-the-creek," etc.

Genus Nyctiardea, Swainson.

*224. *N. grisea nævia* (Bodd.) Allen. Black-crowned Night Heron. Resident southward, at least in mild winters; summer sojourner northward. Familiar names of this species are "Quawk," "Squawk," "Quaw Bird," &c.

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*See Bulletin of the U. S. Geological and Geographical Survey of the Territories, vol. iv, No. 1, pp. 227-37, for remarks bearing upon the probable identity of *Ardea occidentalis*, Aud., and *A. wurdemanni*, Baird.

Genus Nycterodius, Reichenbach.

*225. *N. violaceus* (Linn.) Reich. White-crowned Night Heron*. Summer sojourner in southern portion of the state, breeding at least as far north as Mt. Carmel.

Genus Botaurus, Stephens.

*226. *B. lentiginosus* (Montag.) Steph. American Bittern. Resident southward; summer sojourner northward. Has various popular names, as "Thunder Pump," "Stake Driver," &c.

Genus Ardetta, Gray.

*227. *A. exilis* (Gmel.) Gray. Least Bittern. Summer sojourner, frequenting chiefly marshes and sloughs.

Order LIMICOLÆ.

Family STREPSILIDÆ.—Turnstones.

Genus Strepsilas, Illiger.

228. *S. interpres* (Linn.) Illig. Turnstone. Transient. Common along Lake Michigan.

Family CHARADRIIDÆ.—Plovers.

Genus Squatarola, Cuvier.

229. *S. helvetica* (Linn.) Cuv. Black-bellied Plover. Transient.

Genus Charadrius, Linnæus.

230. *C. dominicus*, Müller. Golden Plover. Transient.

Genus Oxyechus, Reichenbach.

*231. *O. vociferus* (Linn.) Reich. Kill-deer. Resident southward; summer sojourner northward.

Genus Ægialites, Boie.

*232. *Æ. semipalmatus*, Bp. Semipalmated Plover. Transient. Probably breeding in northern portion (Nelson, p. 123).

*233. *Æ. melodus circumcinctus*, Ridgw. Belted Piping Plover. Summer sojourner. Breeding abundantly northward (Nelson, p. 123).

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*Since the above was put in type, I have found this species very common in Knox Co., Indiana, on the line of the O. & M. Railroad, and on April 27 shot a female from her nest, in a tall and slender sweet-gum tree. An egg ready for ejection was found in the oviduct. The species is, at the present time (April, 1881), the commonest heron in this vicinity.

Family SCOLOPACIDÆ.—Snipe, Sandpipes, &c.

Genus Philohela, Gray.

*234. *P. minor* (Gmel.) Gray. American Woodcock. Resident southward; summer sojourner northward.

Genus Gallinago, Leach.

*235. *G. media wilsoni* (Temm.) Ridgw. Common Snipe. Chiefly transient, but breeding in northern portion, and wintering, sparingly, in southern sections. Known by the various names of "English Snipe," "Common Snipe," "Jack Snipe," and curiously, though very appropriately, "Gutter Snipe."

Genus Macrorhamphus, Leach.

236. *M. griseus scolopaceus* (Say) Coues.* Red-breasted Snipe. Transient. Known also as the "Gray Snipe."

Genus Micropalama, Baird.

237. *M. himantopus* (Bp.) Baird. Stilt Sandpiper. Transient; considered very rare in most localities.

Genus Tringa, Linnæus.

238. *T. canutus*, Linn. Red-breasted Sandpiper. Transient. Often called "Robin Snipe" from the "robin-red" breast and lower parts.

Genus Arquatella, Baird.

239. *A. maritima* (Brünn.) Baird. Purple Sandpiper. Transient.

Genus Actodromas, Kaup.

240. *A. maculata* (Vieill.) Coues. Pectoral Sandpiper. Chiefly transient, but a few remain in summer, and probably breed, in the northern portion of the state. Among its several popular names may be cited those of "Jack Snipe" (also applied to *Gallinago wilsoni*), and "Grass Snipe."

241. *A. fuscicollis* (Vieill.) Ridgw. Bonaparte's Sandpiper. Transient, but occasionally occurring northward in summer, and possibly breeding.

242. *A. bairdi*, Coues. Baird's Sandpiper. Transient.

243. *A. minutilla* (Vieill.) Bp. Least Sandpiper. Chiefly transient, but a few remain in summer and probably breed, especially in northern counties. Usually associated with the preceding, which it closely resembles in appearance, the entirely cleft toes of the present species, compared with the partly webbed ones of the other, being the readiest means of distinction.

Genus Pelidna, Cuvier.

244. *P. alpina americana*, Cassin. Red-backed Sandpiper. Transient.

Genus Ereunetes, Illiger.

245. *E. pusillus* (Linn.) Cass. Semipalmated Sandpiper. Transient southward; summer sojourner northward, but probably not breeding (see Nelson, p. 127).

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*I have seen no specimens of this species from Illinois, but all examples which I have examined from other parts of the Mississippi Valley are of the *scolopaceus* type.

Genus Calidris, Cuvier.

246. *C. arenaria* (Linn.) Illig. Sanderling. Transient.

Genus Limosa, Brisson.

247. *L. fœda* (Linn.) Ord. Marbled Godwit. Transient.
248. *L. hæmastica* (Linn.) Coues. Hudsonian Godwit. Transient.

Genus Totanus, Bechstein.

*249. *T. melanoleucus* (Gmel.) Vieill. Larger Yellow-legs. Transient southward; breeding in northern counties (see Nelson, p. 128).

*250. *T. flavipes* (Gmel.) Vieill. Lesser Yellow-legs. Mainly transient, but breeds sparingly northward.

Genus Rhyacophilus, Kaup.

*251. *R. solitarius* (Wils.) Cass. Solitary Sandpiper. Summer sojourner. A common species, frequenting chiefly woodland ponds in company with the Water Thrushes *(Siurus)*, which it much resembles in movements, and known by the popular names of "Peet-weet" (a name also applied to the Spotted Sandpiper, *Tringoides macularius*), "Tilt-up," "Teeter," and "Wood Snipe." Frequently alights on branches of trees or upon fences.

Genus Symphemia, Rafinesque.

*252. *S. semipalmata* (Gmel.) Hartl. Willet. Summer sojourner. Easily distinguished at a distance from the other large snipe by the large white patch on the base of the primary quills, which is particularly conspicuous when the bird is flying.

Genus Bartramia, Lesson.

*253. *B. longicauda* (Bechst.) Bp. Bartram's Tatler. Summer sojourner. Chiefly a prairie bird. Usually known as the "Field Plover," "Upland Plover," or "Prairie Plover."

Genus Tryngites, Cabanis.

254. *T. rufescens* (Vieill.) Caban. Buff-breasted Sandpiper. Transient; rare.

Genus Tringoides, Bonaparte.

*255. *T. macularius* (Linn.) Gray. Spotted Sandpiper. Summer sojourner. Resembling the Solitary Sandpiper in manners, but frequenting chiefly the banks and sand-bars of streams. Also called "Peet-weet" and "Sand Lark."

Genus Numenius, Linnæus.

*256. *N. longirostris*, Wilson. Long-billed Curlew. Transient in most localities. Formerly bred throughout the state, in suitable localities, and still does so in the central and northern districts. Occasionally winters in the extreme southern counties.

257. *N. hudsonicus*, Lath. Hudsonian Curlew. Transient.
258. *N. borealis* (Foster) Lath. Eskimo Curlew. Transient.

Family PHALAROPODIDÆ.—Phalaropes.

Genus PHALAROPUS, Brisson.

259. *P. fulicarius* (Linn.) Bp. Red Phalarope. Transient.

Genus LOBIPES, Cuvier

260. *L. hyperboreus* (Linn.) Cuv. Northern Phalarope. Transient.

Genus STEGANOPUS, Vieillot.

*261. *S. wilsoni* (Sab.) Coues. Wilson's Phalarope. Summer sojourner.

Family RECURVIROSTRIDÆ.—Avocets and Stilts.

Genus RECURVIROSTRA, Linnæus.

*262. *R. americana*, Gmel. American Avocet. Mainly transient, but a few breeding in suitable localities.

Genus HIMANTOPUS, Brisson.

*263. *H. mexicanus* (Müller) Ord. Black-necked Stilt. Mostly transient, but breeding in some localities.

Order GERANOMORPHÆ.

(Geranomorphæ fulicariæ.)

Family RALLIDÆ.—Rails, Gallinules, and Coots.

Genus RALLUS, Bechstein.

*264. *R. elegans*, Aud. Red-breasted Rail. Summer sojourner, sometimes wintering southward. Known as "King Rail," "Mud Hen," "Marsh Hen," &c.

*265. *R. virginianus*, Linn. Virginia Rail. Resident southward; summer sojourner northward.

Genus PORZANA, Vieillot.

*266. *P. carolina* (Linn.) Baird. Carolina Rail. Resident southward; summer sojourner northward. Known as "Common Rail," "Sora," and "Ortolan;" the last two names, however, more frequently applied to it along the Atlantic coast. Of these names, "Sora" is a very good one, not being applied to any other species, so far as known; that of "Ortolan," a name also applied to the Reed Bird *(Dolichonyx oryzivorus)*, and properly applicable only to a European species of Bunting *(Emberiza hortulana)*, is in every way inappropriate.

*267. *P. noveboracensis* (Gmel.) Baird. Little Yellow Rail. Resident, except, perhaps, northward, where possibly only summer sojourner.

*268. *P. jamaicensis* (Gmel.) Baird. Little Black Rail. Resident southward; summer sojourner northward. Breeds, in suitable localities, throughout the state.

Genus Gallinula, Brisson.

*269. *G. galeata*, Licht. Florida Gallinule. Resident, except northward. In some localities known as the "Red-billed Mud Hen," or simply "Mud Hen."

Genus Ionornis, Reichenbach.

*270. *I. martinica* (Linn.) Reich. Purple Gallinule. Summer sojourner. Not common, but occurring throughout the state.

Genus Fulica, Linnæus.

*271. *F. americana*, Gmel. American Coot. Resident, except in northern part of the state. In some places known as the "Mud Hen," "White-billed Mud Hen" (in distinction from the "Red-billed Mud Hen"—*Gallinula galeata*), and "Crow Duck." The latter name is given on account of the shape of the bill.

(Geranomorphæ alectorides.)

Family GRUIDÆ.—Cranes.

Genus Grus, Linnæus.

*272. *G. americana* (Linn.) Temm. Whooping Crane. Mainly transient, but a few breeding on the central prairies (Nelson, p. 133). Less numerous than formerly.

*273. *G. canadensis* (Linn.) Temm. Sandhill Crane. Mainly transient, but breeding on the larger prairies. Much less numerous, and more local, than formerly.

Order ANSERES.

Family ANATIDÆ.—Swans, Geese, and Ducks.

Genus Olor, Wagler.

274. *O. americanus* (Sharpless) Bp. Whistling Swan. Transient; sometimes winter sojourner.

275. *O buccinator* (Richardson) Wagl. Trumpeter Swan. Transient, or occasional winter sojourner.

Genus Chen, Boie.

276. *C. hyperboreus* (Pallas) Boie. Snow Goose. Transient, or occasional winter sojourner.

276*a*. *C. hyperboreus albatus* (Cassin) Ridgw. Lesser Snow Goose. Occurs at the same time as the preceding. Both are commonly known as the "White Brant."

277. *C. cærulescens* (Linn.) Ridgw. Blue Goose. Chiefly transient, but winters in mild seasons.

Genus Anser, Linnæus.

278. *A. albifrons gambeli* (Hartl.) Coues. White-fronted Goose. Transient, but remains in mild winters.

Genus Bernicla, Stephens.

*279. *B. canadensis* (Linn.) Boie. Canada Goose. Chiefly transient, but breeds sparingly, in secluded localities, throughout the state, and sometimes occurs in mild winters.

279*a*. *B. canadensis hutchinsi* (Sw. & Rich.) Ridgw. Hutchins' Goose. Transient; sometimes wintering, but does not breed within the state. Known to some sportsmen as the "Little Gray Goose."

279*b*. *B. canadensis leucoparia* (Brandt) Cass. Little White-cheeked Goose. Occasional visitant (Nelson, Bull. Nutt. Orn. Club, July, 1876, p. 41).

280. *B. brenta* (Pall.) Steph. Brant Goose. A rare winter visitant. This is the true "Brant," and is the rarest of the geese which occur in the interior of the country. It is essentially a salt-water bird, but like *all* the species of the latter class (as the Surf Ducks, Eiders, &c.) occasionally visits the lakes and larger water-courses of the Mississippi Valley. The term "Brant" is applied indiscriminately by gunners to all the smaller geese, including even Hutchins' Goose. It is bestowed most frequently however, upon the White-fronted Goose *(Anser gambeli)*.

Genus Anas, Linnæus.

*281. *A. boscas*, Linn. Mallard. Resident in some localities, but chiefly transient. Commonly known as the "Green-head."

*282. *A. obscura*, Gmel. Dusky Duck; Black Mallard. Resident, or chiefly transient, like the preceding, but very much rarer.

Genus Chaulelasmus, Gray.

*283. *C. streperus* (Linn.) Gray. Gadwall. Chiefly transient, but breeds sparingly, and sometimes remains in mild winters.

Genus Dafila, Leach.

*284. *D. acuta* (Linn.) Bp. Pintail Duck. Mainly transient, but breeds sparingly and sometimes winters.

Genus Mareca, Stephens.

285. *M. penelope* (Linn.) Selby. European Widgeon. An occasional visitant.

*286. *M. americana* (Gmel.) Steph. American Widgeon. Chiefly transient, but breeding in suitable situations. and sometimes wintering. Commonly known as the "Bald-pate."

Genus Spatula.

*287. *S. clypeata* (Linn.) Boie. Shoveller; Spoon-bill Duck. Summer sojourner northward; transient and winter sojourner southward.

Genus Querquedula, Stephens.

*288. *Q. discors* (Linn.) Steph. Blue-winged Teal. Resident, but chiefly transient.

289. *Q. cyanoptera* (Vieill.) Cass. Red-breasted Teal. Occasional visitant. The "Cinnamon Teal" of sportsmen. This species has the most extensive range of any American duck, its regular habitat extending from the Columbia river to Chili and Buenos Ayres. It breeds in South as well as in North America.

Genus Nettion, Kaup.

*290. *N. carolinensis* (Gmel.) Baird. Green-winged Teal. Resident, but chiefly transient.

Genus Aix, Boie.

*291. *A. sponsa* (Linn.) Boie. Summer Duck. Resident southward; summer sojourner northward. Usually known as the "Wood Duck."

Genus Fulix, Sundevall.

292. *F. marila* (Linn.) Baird. Scaup Duck. Winter resident southward; transient northward. Rather rare. Known as the "Black-head" (or "Big Black-head"), "Blue-bill," &c.

*293. *F. affinis* (Eyt.) Baird. Lesser Scaup Duck. Chiefly transient, but breeds in the northern part of the state (*fide* Nelson, p. 141), and winters in the southern portion. Much more abundant than the last. Known as "Little Black-head," &c.

*294. *F. collaris* (Donov.) Baird. Ring-necked Duck. The same remarks apply to this as to the preceding, but it is less numerous. One of the names by which it is most frequently known is that of "Ring-bill."

Genus Æthya, Boie.

295. *Æ. vallisneria* (Wils.) Boie. Canvass-back Duck. Transient, or occasionally wintering.

296. *Æ. americana* (Eyt.) Bp. American Pochard. Transient; occasionally wintering. The "Red-head" of sportsmen.

Genus Clangula, Fleming.

297. *C. islandica* (Gmel.) Bp. Barrow's Golden-eye. Winter sojourner. Occurs throughout the state.

298. *C. glaucium americana* (Bp.) Ridgw. American Golden-eye. Winter sojourner.

299. *C. albeola* (Linn.) Steph. Buffle-head. Winter sojourner. Has various popular names, as "Butter-ball," "Di-dipper," &c.

Genus Histrionicus, Lesson.

300. *H. minutus* (Linn.) Dresser. Harlequin Duck. Winter sojourner. Occurring throughout the state.

Genus Harelda, Leach.

301. *H. glacialis* (Linn.) Leach. Long-tailed Duck. Winter sojourner. Occurs, like the last, throughout the state on the larger streams.

Genus Somateria, Leach.

302. *S. mollissima dresseri* (Sharpe) Coues. American Eider. Winter visitant, chiefly on Lake Michigan.

303. *S. spectabilis* (Linn.) Boie. King Eider. Rare winter visitant (see Nelson, p. 143).

Genus Œdemia, Fleming.

304. *Œ. americana* (Sw. & Rich.) Black Scoter. Winter sojourner, chiefly on Lake Michigan.

Genus MELANETTA, Boie.

305. *M. velvetina* (Cass.) Baird. Velvet Scoter. Winter sojourner; of general distribution, but most numerous on Lake Michigan.

Genus PELIONETTA, Kaup.

306. *P. perspicillata* (Linn.) Kaup. Surf Duck. Winter sojourner; occurring on all the larger streams, as well as upon Lake Michigan.

Genus ERISMATURA, Bonaparte.

*307. *E. rubida* (Wilson) Bp. Ruddy Duck. Resident southward; summer sojourner northward.

Genus MERGUS, Linnæus.

308. *M. merganser americanus* (Cass.) Ridgw. Buff-breasted Sheldrake. Winter sojourner.

*309. *M. serrator*, Linn. Red-breasted Merganser. Resident, but chiefly transient; breeds (in northern counties) and winters (whole state) sparingly.

Genus LOPHODYTES, Reichenbach.

*310. *L. cucullatus* (Linn.) Reich. Hooded Sheldrake. Resident throughout the state; breeds everywhere, in suitable localities. Almost as truly arboreal as *Aix sponsa* (Summer Duck).

Order STEGANOPODES.

Family PELECANIDÆ.—Pelicans.

Genus PELECANUS.

311. *P. erythrorhynchus*, Gmel. American White Pelican. Transient.

312. *P. fuscus*, Linn. Brown Pelican. Accidental. One seen at Lima Lake, near Warsaw, Hancock county, by C. K. Worthen, in October, 1873. (See Bull. Nutt. Orn. Club, January, 1880, p. 31.)

Family PHALACROCORACIDÆ—Cormorants.

Genus PHALACROCORAX, Brisson.

313. *P. dilophus* (Sw. & Rich.) Nutt. Double-crested Cormorant. Rare winter sojourner, but chiefly transient.

*313*a*. *P. dilophus floridanus* (Aud.) Ridgw. Florida Cormorant; "Black Loon." Summer sojourner. Abundant southward, where sometimes resident; rare northward.

314. *P. mexicanus* (Brandt) Scl. & Salv. Mexican Cormorant. Summer visitant to extreme southern portion (Cairo, *fide* C. K. Worthen; see Bull. Nutt. Orn. Club, January, 1880, p. 31).

Family PLOTEIDÆ.—Anhingas or Darters.

Genus PLOTUS, Linnæus.

*315. *P. anhinga*, Linn. Snake Bird. Summer sojourner in extreme southern part of the state. Commonly known as the "Water Turkey."

F

Order GAVIÆ.

Family LARIDÆ.—Gulls and Terns.

Genus Rissa, Leach.

316. *R. tridactyla* (Linn.) Bp. Kittiwake Gull. Winter visitant to Lake Michigan.

Genus Larus, Linnæus.

317. *L. glaucus*, Brünn. Glaucous Gull. Winter visitant to Lake Michigan.

318. *L. leucopterus*, Fabr. Winter sojourner on Lake Michigan.

319. *L. marinus*, Linn. Great Black-backed Gull. Winter visitant to Lake Michigan.

320. *L. argentatus*, Brünn. European Herring Gull. Rare (or accidental) winter visitant to Lake Michigan (see Nelson, p. 145).

*320*a*. *L. argentatus smithsonianus*, Coues. American Herring Gull. Winter sojourner throughout the state. A few remain in summer, on or near the larger bodies of water, but probably do not breed in our limits.

321. *L. delawarensis*, Ord. Ring-billed Gull. Mainly transient, but winter sojourner southward, and rare summer sojourner (but not breeding ?) northward.

322. *L. atricilla*, Linn. Laughing Gull. Rare summer visitant southward.

323. *L. franklini*, Sw. & Rich. Franklin's Gull. Transient.

324. *L. philadelphiæ* (Ord.) Gray. Bonaparte's Gull. Chiefly transient, but sometimes wintering, while a few apparently remain in summer in certain localities.

Genus Xema, Leach.

325. *X. sabinei* (J. Sabine) Leach. Fork-tailed Gull. Rare winter visitant to Lake Michigan.

Genus Sterna, Linnæus.

326. *S. anglica*, Montag. Marsh Tern. Rare summer visitant.

327. *S. caspia*, Pall. Caspian Tern. Winter visitant.

328. *S. regia*, Gamb. Royal Tern. Summer visitant.

*329. *S. fluviatilis*, Naum. Common Tern. Mostly transient; abundant in suitable places, especially northward, where a few breed.

*330. *S. forsteri*, Nutt. Forster's Tern. Summer sojourner.

331. *S. antillarum* (Less.) Coues. Least Tern. Summer visitant.

Genus Hydrochelidon, Boie.

*332. *H. lariformis surinamensis* (Gmel.) Ridgw. Black Tern. Summer sojourner. The most numerous and generally diffused species of the family.

Family STERCORARIIDÆ.—The Skuas and Jaëgers.

Genus Stercorarius, Brisson.

333. *S. pomatorhinus* (Temm.) Pomarine Jaëger. Winter visitant to Lake Michigan (Nelson, p. 145).

334. *S. parasiticus* (Linn.) Saunders. Long-tailed, or Buffon's Jaëger. Casual winter visitant. (See Bull. Nutt. Orn. Club, January, 1880, p. 31.)

Order PYGOPODES.

Family PODICIPEDIDÆ.

Genus Podiceps, Latham.

335. *P. holbölli*, Reinh. American Red-necked Grebe. Winter sojourner.

Genus Dytes, Kaup.

*336. *D. auritus* (Linn.) Ridgw. Horned Grebe. Chiefly transient, but wintering southward and a few breeding northward.

337. *D. nigricollis californicus* (Heerm.) Ridgw. American Eared Grebe. Winter sojourner.

Genus Podilymbus, Lesson.

/ *338. *P. podiceps* (Linn.) Lawr. Thick-billed Grebe. Summer sojourner northward; resident in southern counties.

Family COLYMBIDÆ.—Loons.

Genus Colymbus, Linnæus.

*339. *C. torquatus*, Brünn. Great Northern Diver; Loon. Chiefly winter sojourner, but nests very sparingly in extreme northern portion of the state.

340. *C. arcticus*, Linn. Black-throated Diver. Rare winter visitant.

341. *C. septentrionalis*, Linn. Red-throated Diver. Winter sojourner.

APPENDIX.

LIST OF SPECIES WHICH PROBABLY OCCUR IN ILLINOIS, BUT WHICH HAVE NOT YET BEEN ACTUALLY TAKEN WITHIN THE LIMITS OF THE STATE.

TURDIDÆ.—Thrushes.

Genus Hesperocichla, Baird.

1. *H. nævia* (Gmel.) Baird. Oregon Robin.—N. W.* Iowa (Allen, White's Geol. Surv. Iowa, 1870, II., p. 419); New Jersey (Turnbull, Birds E. Penn. and New Jersey, 1869, 41; Allen, Pr. Essex Inst., 1864, 82); Long Island, N. Y. (Lawrence, Ann. Lyc. N. Y., 1866, 281); Ipswich, Mass., Del., 1864 (Allen, Am. Nat., 1869, 572; Maynard, Nat. Guide, 1870, 89). Probably a winter visitant.

SITTIDÆ.—Nuthatches.

Genus Sitta, Linnæus.

2. *S. pusilla*, Lath. Brown-headed Nuthatch.—S. E. To be looked for among the pine-clad hills in the extreme southern part of the state. (Has been recorded from St. Louis, Mo., and Ohio.)

MOTACILLIDÆ.—Wagtails and Titlarks.

Genus Neocorys, Sclater.

3. *N. spraguei* (Aud.) Scl. Sprague's Lark.—W. Undoubtedly occurs on the prairies during migrations, or in winter. A strictly prairie bird.

MNIOTILTIDÆ.—American Warblers.

Genus Helminthophaga, Cabanis.

4. *H. bachmani* (Aud.) Caban. Bachman's Warbler.—S. E. (South Carolina and Florida.)

Genus Perissoglossa, Baird.

5. *P. carbonata* (Aud.) Baird. Carbonated Warbler. Discovered by Audubon in Kentucky, and therefore extremely likely to occur in Southern Illinois. Known only from Audubon's description and figures.

Genus Dendrœca, Gray.

6. *D. kirtlandi*, Baird. Kirtland's Warbler. A very rare species, originally discovered in Ohio (where specimens have more recently been obtained, as well as in Michigan and in the Bermudas).

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*The range of the species is indicated by initials, as N. W., S. E., &c., for the northwestern, southeastern, and other portions of the continent.

FRINGILLIDÆ.—Finches.

Genus Centrophanes, Kaup.

7. *C. ornatus* (Towns) Caban. Chestnut-collared Longspur.—W. Undoubtedly to be found on the prairies, especially in northwestern portion of the state. Strictly a prairie bird.

Genus Chrysomitris, Boie.

8. *C. notata* (Du Bus) Bp. Mexican Black-headed Goldfinch. Obtained by Audubon at Henderson, Kentucky (the "*C. magellanicus*" of Audubon's works), and possibly straggles to Southern Illinois.

Genus Centronyx, Baird.

9. *C. bairdi* (Aud.) Baird. Baird's Bunting.—W. To be sought for on the larger prairies. An inconspicuous species, easily overlooked.

Genus Passerculus, Bonaparte.

10. *P. princeps*, Maynard. Ipswich Sparrow.—N. E. To be looked for among the sand-hills along the lake shore.

Genus Ammodromus, Swainson.

11. *A. maritimus* (Wilson) Sw. Sea-side Finch.—E. Should be looked for in the grassy marshes of the northeastern portion of the state, where it doubtless occurs along with *A. caudacutus*.

Genus Zonotrichia, Swainson.

12. *Z. coronata* (Pall.) Baird. Golden-crowned Sparrow.—N. W. Taken at Racine, Wisconsin, in April, 1858, by Dr. Hoy (Nelson, p. 108).

Genus Zamelodia, Coues.

13. *Z. melanocephala* (Swains.) Coues. Black-headed Grosbeak.—W. Has been obtained in Michigan (Fox; reference not at hand).

Genus Calamospiza, Bonaparte.

14. *C. bicolor* (Towns.) Bp. Lark Bunting.—W. A bird of the Great Plains, and undoubtedly occurring on the prairies of Illinois.

Genus Peucæa, Audubon.

15. *P. cassini* (Woodh.) Baird. Cassin's Finch.—S. W. Has been obtained as far north as the prairies of middle Kansas (Allen, Bull. Mus. Comp. Zool., 1872, 137), and may straggle to southwestern Illinois.

Genus Passerina, Vieillot.

16. *P. versicolor* (Bp.) Gray. Varied Bunting.—S. W. (Has been taken in Michigan)

CORVIDÆ.—Crows and Jays.

Genus Corvus, Linnæus.

17. *C. cryptoleucus*, Couch. White-necked Raven.—S. W. A species readily distinguishable from the common Raven only by its smaller size, all the white of its plumage being on the *bases* of the feathers, and entirely concealed. Known range extends from Western Texas to Wyoming. May occur in Southwestern Illinois.

18. *C. ossifragus*, Wils.—S. and E. A species supposed to be peculiar to the vicinity of the sea-coast, but possibly ascending the Mississippi and its larger affluents as far as Southern Illinois (see note on page 183).

Genus Perisoreus, Bonaparte.

19. *P. canadensis* (Linn.) Bp. Canada Jay.—N. Obtained by Dr. Hoy, near Racine, Wisconsin, in the winter of 1859 (Nelson, p. 113). Possibly a very rare winter visitant to the extreme northern portion of the state.

Genus Aphelocoma, Cabanis.

20. *A. floridana* (Bartr.) Caban. Florida Jay.—S. E. The Florida Jay is considered to be peculiar to a limited portion of the peninsula of Florida; but we see no reason to suppose that its range is thus restricted. The laws of geographical distribution most emphatically suggest a wider distribution. Indeed, it has been recorded from Kentucky by certain authors; and, though the evidence upon which this record was based appears insufficient, it seems extremely probable that, like *Peucæa æstivalis*, it may eventually be discovered far beyond its previously known range. It is a species which inhabits thickets of bushes or low trees, and should be carefully looked for in such localities, which, in the form of "oak barrens" and the scrubby growth of crab-apple, wild plum, &c., abound in the southern part of Illinois.

TYRANNIDÆ.—Tyrant Flycatchers.

Genus Tyrannus, Cuvier.

21. *T. vociferans*, Swains. Cassin's Kingbird.—S. W. A bird of the Great Plains, ranging as far north as Cheyenne, Wyoming. May occur in the semi-prairie districts of Western Illinois.

22. *T. verticalis*, Say. Western Kingbird.—W. A great wanderer, having been obtained at many eastern localities, as Iowa (Allen, Mem. Boston Soc., I., 1868, 498); New Jersey (Turnbull, Birds E. Penn. & N. J., 1869, 41); Maine (Bryant, Pr. Boston Soc., 1865, 96); and District of Columbia (Jouy, *Field and Forest*, April, 1877, p. 178).

Genus Milvulus, Swainson.

23. *M. tyrannus* (Linn.) Bp. Fork-tailed Flycatcher.—S. A tropical species, but a great wanderer, having been obtained in several of the eastern United States; e. g. Henderson, Kentucky, New Jersey, and Mississippi (Audubon).

24. *M. forficatus* (Gmel.) Sw. Scissor-tailed Flycatcher.—S. W. Essentially a southern species (but chiefly Mexican), and, like the preceding, a great wanderer. Common in the semi-prairie districts from Texas to the Indian territory, where known as the "Scissor-tail," and "Bird of Paradise." Has occurred at Fort Riley, Kansas (Snow, Catal. Birds Kansas, 1873, 3), and at Trenton, New Jersey (Abbott, Am. Nat. 1872, 367).

CAPRIMULGIDÆ.—Goatsuckers.

Genus Phalænoptilus, Ridgway.

25. *P. nuttalli* (Aud.) Ridgw. Poor-will.—W. Breeds as far east as Eastern Kansas (Allen, Bull. Mus. Comp. Zool., II., 1872, 179; Snow, Catal. Birds Kansas, 1872–3, 3). If occurring in Illinois, would be found on the dryer prairies.

PICIDÆ.—Woodpeckers.

Genus PICUS, Linnæus.

26. *P. querulus*, Wils. Red-cockaded Woodpecker.—E. and S. A species partial, if not peculiar, to pine woods, and therefore likely to be found in the extreme southern part of the state.

Genus PICOIDES, Lacépede.

27. *P. tridactylus americanus* (Brehm) Ridgw. Banded Three-toed Woodpecker.—N. Probably a rare winter visitant to the extreme northern part of the state.

STRIGIDÆ.—Owls.

Genus NYCTALE, Brehm.

28. *N. tengmalmi richardsoni* (Bp.) Ridgw. Richardson's Owl.—N. Probably a rare winter visitant to extreme northern counties. Has been obtained in Wisconsin by Dr. Hoy (*fide* Coues, Birds Northwest, p. 314), while Mr. Allen gives it as found in Iowa*.

Genus SPEOTYTO, Gloger.

29. *S. cunicularia hypogæa* (Bp.) Ridgw. Burrowing Owl.—W. A species of the plains and open country, breeding regularly as far east as Fort Hays, Kansas (Allen, Bull. Mus. Comp. Zool., III., 1872, 180; Snow, Catal. Birds Kansas, 1872, 2). Has also been obtained in Eastern Massachusetts and near New York city (references not at hand).

FALCONIDÆ.—Hawks, &c.

Genus ÆSALON, Kaup.

30. *Æ. richardsoni*, Ridgw. Richardson's Merlin —N. W. A species occurring throughout the whole extent of the Great Plains, and therefore likely to occur in any prairie district. Has been obtained in Kansas (spec. in U. S. Nat. Mus.), and in Michigan. (*F. æsalon*, Fox,—reference forgotton, and not now accessible to the writer.)

TETRAONIDÆ.—Grouse.

Genus CANACE, Reichenbach.

31. *C. canadensis* (Linn) Bp. Spruce Grouse.—N. Possibly a rare winter visitant to extreme northern portion.

CHARADRIIDÆ.—Plovers.

Genus PODASOCYS, Coues.

32. *P. montanus* (Towns.) Coues. Mountain Plover.—W. Possibly occurs on the dryer upland prairies. Has been obtained in Florida (Maynard; reference not at hand), and is a common species of the Great Plains west of the Missouri river.

Genus ÆGIALITES, Boie.

33. *Æ. melodus* (Ord.) Bp. Piping Plover.—E. Although we are unable to give authority for the occurrence in Illinois of the typical form of this species,

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*In his Catalogue of the Birds of Iowa, in White's Geol. Survey of Iowa.

in which the black on the breast of the male is confined to two widely separated bars on each side, it undoubtedly occurs as a straggler, and should be looked for, especially along the lake shore.

IBIDIDÆ.—Ibises.

Genus Plegadis, Kaup.

34. *P. guarauna* (Linn.) Ridgw. White-faced Glossy Ibis.—S. W. Abundant throughout the west, in suitable localities, from the lower Rio Grande to the Columbia river, and doubtless straggles occasionally through the Mississippi Valley.

ARDEIDÆ.—Herons.

Genus Hydranassa, Baird.

35. *H. tricolor ludoviciana* (Wils.) Ridgw. Louisiana Heron.—S. Undoubtedly occurs in Southern Illinois. Has been observed in Indiana (near Hanna, June, 1876; see Nelson, Bull. Nutt. Orn. Club, April, 1877, p. 51.)

ANATIDÆ.—Ducks, Geese, and Swans.

Genus Chen, Boie.

36. *C. rossi* (Baird) Ridgw. Ross's Snow Goose.—N. W. Possibly an occasional straggler in winter.

Genus Dendrocycna, Swainson.

37. *D. fulva* (Gmel.) Burm. Fulvous Tree Duck.—S. W. Possibly occurs in the extreme south of the state.

Genus Nomonyx, Ridgway.

38. *N. dominicus* (Linn.) Ridgw. Masked Duck.—S. Has been obtained in Wisconsin and at Lake Champlain (references not at hand).

LARIDÆ.—Gulls, Terns, and Jaëgers.

Genus Sterna, Linnæus.

39. *S. dougalli*, Montag. Rosy Tern.—E. An Atlantic coast species, very likely to occur on Lake Michigan. Is recorded from Northern Ohio (Wheaton, Ohio Agric. Rep., 1860, 275).

40. *S. macrura*, Naum. Arctic Tern.—N. Doubtless a winter visitant to the northern portion of the state. Is recorded from Northern Ohio (Wheaton, l. c., 274).

Genus Hydrochelidon, Boie.

41. *H. leucoptera* (Weisn. & Schinz) Boie. White-winged Black Tern.—European Straggler. Possibly occurring as a straggler. Has been obtained in Wisconsin (Coues, Check List, 1873, 575 *bis*.]

PODICIPEDIDÆ.—Grebes.

Genus Æchmophorus, Coues.

42. *Æ. occidentalis* (Lawr.) Coues. Western Grebe.—W. Possibly occurring on the larger bodies of water.

DESCRIPTIVE CATALOGUE

OF

North American Batrachia and Reptilia,

FOUND EAST OF MISSISSIPPI RIVER.

BY N. S. DAVIS, JR., AND FRANK L. RICE.

BLOOMINGTON, ILL..
PANTAGRAPH PRINTING ESTABLISHMENT.
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The students of general herpetology in this country have labored under great disadvantage, as the descriptions of American Batrachia and Reptilia are scattered through many works, which are rarely found except in large scientific libraries. In the following pages an attempt is made to describe, in convenient form, the species found in Eastern North America, and the higher groups to which they belong. The nomenclature and classification used are the same as that adopted by Prof. E. D. Cope in his *Check List of North American Batrachia and Reptilia.* (Bull. of U. S. Nat. Mus., No. 1.) In order to facilitate the identification of specimens, and in order that the catalogue may be available to the greatest number, when easily recognizable characters did not exist in the natural synopses, they were added in artificial ones.

The works of the following authors have been especially useful in preparing the present paper: E. D. Cope, Baird, Girard, Agassiz, Holbrook, Huxley, Dumeril, Bibron, Gray's and Gunther's British Museum Catalogues, also the reports of the government exploring expeditions, the volumes of the Proceedings of the Philadelphia Academy of Sciences, etc.

Many of the synopses have been compiled from the numerous exhaustive articles by Prof. Cope, several of which have been copied in part almost verbatim. The compilers are much

indebted to the Northwestern University, and to the Chicago Academy of Sciences, for free access to their museums and libraries. They also feel under especial obligation for assistance of various kinds to Professors S. A. Forbes, Oliver Marcy, S. F. Baird, Mr. R. E. Earll, D. S. Jordan, and Doctors J. W. Velie and P. R. Hoy. In those instances in which the distribution of species has been extended beyond that given in Prof. Cope's check list, the new locality is noted in italics. Preceding the glossary which is appended to the catalogue, will be found a description of the faunal regions of the United States, as limited by Prof. Cope.

SYNOPSIS OF CLASSES.

Mammary glands absent; blood cold; not less than two aortic arches; no fin rays.

a. Respiration through whole or part of life effected by means of branchiæ; lungs present in adult; two occipital condyles; no thoracic diaphragm; usually no scales or scutes, when present they are imbedded in skin; limbs, when present, well developed, with two or more digits; heart trilocular; no sternal ribs; undergo metamorphosis after leaving egg....... *Batrachia.*

b. Respiration never effected by means of branchiæ, but after birth performed by lungs; no separate parasphenoid; a single convex occipital condyle; sometimes an incomplete thoracic diaphragm; body usually covered with scales or bony plates; metatarsal bones not anchylosed together or with distal tarsal bones; venous and arterial currents of blood mingled either in the heart itself, or at the origin of the aortic arches; undergo no metamorphosis after leaving egg.................... *Reptilia.*

BATRACHIA.

SYNOPSIS OF ORDERS.

A. Tail present; inferior pelvic elements not consolidated into a single vertical mass; proximal elements of tarsus not elongated; frontals not confluent with parietals.

- *a.* Dentaries and premaxillæ without teeth, covered with horny plates; two ethmoids, forming part of palate laterally; maxillaries, prefrontals, palatines, and pterygoids wanting; nasals present; posterior extremities absent; branchiæ persistent. . . . . *Trachystomata.*
- *b.* Dentaries and premaxillæ toothed; two vertical ethmoids, one on each side of cerebral lobes; posterior extremities present.
  - *x.* Maxillaries, prefrontals, and nasals wanting; pterygoids and palatines present; branchiæ persistent. . . . . *Proteida.*
  - *y.* Usual cranial bones present; pterygoids and prefrontals sometimes absent; branchiæ wanting when completely developed. . *Caducibranchiata.*

B. Tail absent in adult; coccyx represented by a single long cyclindrical bone; inferior pelvic elements consolidated into a single vertical mass; proximal elements of tarsus much elongated; frontals confluent with parietals; ethmoid, a ring usually ossified above, surrounding cerebral lobes; limbs four; body short, depressed. . . . . *Anura.*

Order TRACHYSTOMATA.

Family SIRENIDÆ.

Premaxillæ not anchylosed; two groups of vomerine teeth; parasphenoid edentulous; occipital condyles sessile; four persistent branchial arches; tongue free in front and on sides; eyes small; eye-lids not well developed; vertebræ amphicœlian; car-

pus cartilaginous; metacarpals five. Head elongate; tail compressed.

Toes four; color uniform. . . . . *Siren.*

Toes three; with longitudinal bands or stripes. *Pseudobranchus.*

Genus Siren, Linn.

1. *S. lacertina*, Linn. Great Siren. Color dusky, approaching to black, with numerous white or yellowish spots; abdomen purplish; eleven inches. Austroriparian region, North Carolina, Mexico, and *Northeastern Illinois.*

Genus Pseudobranchus, Gray.

2. *P. striatus*, LeConte. Striped Siren. Color dusky, with a broad yellow or brown stripe on each side; abdomen speckled with brownish white, and with two longitudinal stripes paler than those above; nine inches. Georgia.

Order PROTEIDA.

Family PROTEIDÆ.

Premaxillæ not anchylosed; vomero-palatine teeth; parasphenoid edentulous; occipital condyles sessile; three persistent branchial arches; tongue large and fleshy, free in front and on sides; eyes small, distinct; eyelids none; vertebræ amphicœlian; carpus and tarsus cartilaginous; metacarpals three; head elongate; trunk short and thick; toes four on each foot.

Order CADUCIBRANCHIATA.

Synopsis of Families.

A. Teeth on anterior or outer margin of palatines. Prefrontals and pterygoids present; carpus and tarsus cartilaginous; vertebræ amphicœlian.

a. An axial cranial bone in front of ethmoid, and one forming palatal surface in front of parasphenoid; parietals prolonged laterally, not reaching prefrontals; premaxillæ anchylosed; occipital condyles pedicellate; a single gill-cleft on each side . . . . *Amphiumidæ.*

b. No anterior axial cranial bone; parietals and prefrontals prolonged, meeting and embracing frontals; premaxillaries separated; occipital condyles sessile; gill-clefts

present or absent . . . . *Menopomidæ.*

B. Teeth on posterior or inner margin of palatines; no anterior axial bone; gill-clefts closed in completely developed specimens.

a. Vertebræ amphicœlian; parietals embracing frontals; palatines with teeth on their posterior portion, not prolonged over parasphenoid; occipital condyles sessile.

x. Carpus and tarsus osseous; parasphenoid without dentigerous plates; pterygoids present; prefrontals prolonged and embracing frontals. *Amblystomidæ.*

y. Carpus and tarsus cartilaginous; parasphenoid with dentigerous plates; pterygoids wanting; prefrontals not prolonged or embracing frontals. *Plethodontidæ.*

b. Vertebræ opisthocœlian; parietals not embracing frontals.

x. Carpus and tarsus cartilaginous; palatines with teeth on their posterior portion, not prolonged over the dentigerous parasphenoid; pterygoids and prefrontals wanting; occipital condyles pedicellate . . . . *Desmognathidæ.*

y. Carpus and tarsus osseous; palatines with teeth on the inner margin of the separate processes which extend backward over the non-dentigerous parasphenoid; pterygoids and prefrontals present; occipital condyles sessile. . . . . *Pleurodelidæ.*

Artificial Synopsis of Families.

A. An opening on side of neck.

a. Limbs small; toes 2–2 or 3–3. . . . . *Amphiumidæ.*

b. Limbs well developed; toes 4–5 . . . . *Menopomidæ.*

B. No opening on side of neck when completely developed.

a. No patches of teeth (parasphenoid) on middle of roof of mouth behind; one or more series (palatine), usually transversely arranged, in front. . . . . *Amblystomidæ.*

b. Patches of teeth (parasphenoid) on middle of mouth behind. Without a row of large red spots on the sides.

x. Characters not combined as in the following. *Plethodontidæ.*

y. Anterior margin of tongue attached; toes 4–5; costal folds not over 15; tail compressed and finned above and no dorsal band, or parasphenoid patches of teeth well separated and a yellowish dorsal band. . . . . *Desmognathidæ*

c. Teeth on roof of mouth consisting of two longitudinal rows (palatine), which approach in front and diverge at back of mouth; usually with a row of large red spots on the sides. . . . . *Pleurodelidæ*.

Family AMPHIUMIDÆ.

Toes two on each foot. . . . . *Amphiuma*.
Toes three on each foot. . . . . *Murænopsis*.

Genus AMPHIUMA, Linn.

5. *A. means*, Linn. Congo Snake. Color above brownish to slate color; beneath paler; one and one-half feet long. From Mississippi to North Carolina.

Genus MURÆNOPSIS, Fitz.

6. *M. tridactylus*, Cuvier. Color above brown to dark gray; beneath paler. Mississippi to Louisiana.

Family MENOPOMIDÆ.

Genus MENOPOMA, Harl.

Palatine and maxillary teeth almost parallel; tongue transversely oval; limbs short and thick; toes 4–5, the two outer with membranous fringes; gill-clefts present.

7. *M. allegheniense*, Harl. Hell-bender. Body cinerous, with dusky blotches; length, one and one-half to two feet. Tributaries of Mississippi, and streams of Louisianian district to North Carolina.

8. *M. fuscum*, Holbrook. Body uniform umber; pale beneath. Headwaters of Tennessee river.

Family AMBLYSTOMIDÆ.

Genus AMBLYSTOMA, Tschudi.

Palatine series of teeth in the same line, though often interrupted; quadrato-jugal bone wanting; tongue large and thick, with a narrow free margin, except posteriorly. A series of mucous pores around and anterior to orbit. Digits 4-5, not webbed.

A. Palatine series of teeth extending laterally behind internal nares; plicæ of tongue radiating from its posterior portion. Par-

otoid glands not forming an ovoid distinct mass. Four phalanges in fourth toe.

a. Costal grooves 10; palatine series in three patches.

9. *A. talpoideum*, (Holbr.) Gray. Mole Salamander. Head broad, width contained about three and five-tenths times in distance from snout to groin; external nares much closer together than internal; palatine series of teeth convex backwards; tail short, compressed; patches of large pores on head; color brown or blackish above, paler beneath, irregularly marked with gray of a lichen-like character; dusky spots on back and tail; L. three and one-half inches. Austroriparian region; mountains of South Carolina.

b. Costal grooves 11; palatine series of teeth three.

x. No or one indistinct plantar tubercle.

10. *A. opacum*, (Graven) Bd. Opaque Salamander. Middle series of teeth transverse or concave, behind posterior margin of nares; width of head in specimens three inches long, less than four times in distance from snout to groin; in adults, four and seven-tenths times; no regular patches of conspicuous pores on head and parotoids. Black, with a dorsal series of transverse grayish bands about fourteen in number, which are sometimes more or less confluent and sometimes interrupted medially; L. three and one-half inches. From Pennsylvania to Florida; Wisconsin and Texas.

11. *A. punctatum*, (Linn) Bd. Large Spotted Salamander. Teeth as in the last; width of head in small specimens, three and five-tenths times to groin; in adults, four and five-tenths times; patches of conspicuous pores on head and parotoids; a deep dorsal groove; black, with a series of round bright yellow spots on each side of back; in alcoholic specimens, brown above with white spots; L. six inches. United States east of the plains; Nova Scotia.

12. *A. conspersum*, Cope. Smaller Spotted Salamander. Middle series of teeth convex, advancing beyond posterior margin of nares; width of head about four and five-tenths times in distance to groin; skin smooth; body quite free from visible pores; no distinct dorsal groove; color above, leaden beneath paler; sides with one or two series of small whitish spots; L. two and two-thirds inches. Pennsylvania to Georgia.

y. Plantar tubercles two, distinct.

13. *A. bicolor*, Hallowell. Middle series of teeth straight, nearly divided; external nares much closer together than internal; width of head more than one-quarter distance to groin; tail short, much compressed; dorsal furrow slight; color above, olive brown;

beneath, yellowish, which rises on the sides as short blotches, above these several ill-defined yellowish spots; parotid region yellow; tail yellow with dark spots; limbs cross-banded; L. six inches. New Jersey.

c. Costal grooves 12; mucous pores each side of muzzle.

x. Two distinct plantar tubercles; size large.

14. *A. tigrinum*, (Green) Bd. Tiger Salamander. No canthus rostralis; head long; external nares closer together than internal; tooth series continuous or slightly interrupted, generally convex forwards; parotid region much swollen; color usually blackish-brown, with irregular scattered spots or blotches of yellow; those on lower part of sides largest, subquadrate, and more or less confluent; sometimes uniform brown above and yellow below; sometimes entirely yellow, with brown linear patches; L. eight inches. United States east of the plains.

15. *A. xiphias*, Cope. Long-tailed Salamander. Canthus rostralis distinct; tail longer than head and body; external nares closer together than internal; muzzle obtuse; head small and short, width five times in distance to groin; palatine teeth in one series, slightly convex forwards; mandible projecting beyond muzzle; color above yellowish-olive; beneath brighter yellow; back and sides with reticulating bands of brown; a few rounded spots of the same on the belly; L. eleven and one-quarter inches; tail six. Ohio.

y. No or one indistinct plantar tubercle; size small; palatine series of teeth interrupted.

16. *A. jeffersonianum*, subsp. *jeffersonianum*, (Green) Cope. External and internal nares equidistant; width of head four and five-tenths to five times in distance to groin; dorsal groove indistinct; eyes situated far back; tooth series transverse, in four patches; distance between anterior corners of eyes more than twice the length of orbital fissure; lead colored to black; with or without pale bluish spots on sides; L. five and five-tenths inches. Pennsylvania and Ohio northward.

17. *A. jeffersonianum*, subsp. *laterale*, (Hall) Cope. Middle patches of teeth convex forward; distance between anterior corners of eyes only twice length of orbital fissure; color black, with large white spots on sides and tail; smaller ones below; L. about one-half the preceding. In other respects like the last. Canada and Wisconsin northward; *Northern Illinois*.

18. *A. jeffersonianum*, subsp. *fuscum*, (Hall) Cope. Color dark brown, with a darker shade or band along sides; L. three and eight-tenths. Indiana and Virginia.

19. *A. jeffersonianum*, subsp. *platineum*, Cope. Width of head five and five-tenths to six times in length to groin; tooth series slightly convex; lead-colored above; paler below, with or without indistinct whitish blotches. Ohio; *Southwest Illinois.*

B. Palatine series of teeth not extending laterally behind inner nares; plicæ of tongue radiating from a median longitudinal furrow; no distinct parotoid mass; four phalanges in fourth toe; no canthus rostralis; species small; costal grooves 14.

20. *A. cingulatum*, Cope. Mandible shorter than muzzle; head elongate; width between eyes behind equal to distance from same to nares; width of head six and a half times in distance to groin; a strongly marked dorsal groove; palatine teeth entirely between inner nares; color black; beneath thickly speckled with gray; a vertical gray line between each pair of costal folds, which either meet the opposite one on the median line, or bifurcate to meet a similar bifurcation on the back; the annuli thus formed extend from head to end of tail; L. three and one-half inches. South Carolina.

21. *A. microstomum*, Cope. Mandible longer than muzzle; head short; width between eyes behind equal to distance from same to end of muzzle; body stouter than preceding; width of head six and a half to seven times in distance to groin; dorsal groove slight; color brownish-black, paler beneath; usually with thickly and irregularly sprinkled spots or patches of plumbeous on sides, and less numerous spots above and below; L. four inches. Eastern region, west of Alleghanies.

Family PLETHODONTIDÆ.

Synopsis of Genera.

A. Tongue attached from the central or posterior pedicel to anterior margin in a narrower or wider band; maxillary normal, with small teeth; parietals fully ossified.

a. Two premaxillary bones, with fontanelle.

x. Digits 4–4 .... *Hemidactylium.*

y. Digits 4–5 .... *Plethodon.*

b. One premaxillary, without fontanelle. Digits 4–5. *Stereochilus.*

B. Tongue free all around, attached only by the central pedicel; parietals well ossified; digits free.

a. One premaxillary, with fontanelle.

x. Digits 4–4 .... *Manculus.*

y. Digits 4–5 .... *Spelerpes.*

b. Two premaxillaries, with fontanelle. Digits 4–5. *Gyrinophilus.*

Artificial Synopsis of Genera.

A. Anterior margin of tongue attached.
a. Toes 4–4 . . . . *Hemidactylium.*
b. Toes 4–5.
x. Tail rounded and not finned, or with costal folds not over 14 . . . . *Plethodon.*
y. Tail compressed and finned above; costal folds 17; pale-yellow, brown-lined . . . . *Stereochilus.*
B. Tongue free on all sides.
a. Toes 4–4 . . . . *Manculus.*
b. Toes 4–5.
x. Yellow or red above, spotted or lined with black or brown; or with not more than 12 costal folds. *Spelerpes.*
y. Uniform purple-gray above; costal folds 14. *Gyrinophilus.*

Genus Hemidactylium, Tsch.

22. *H. scutatum*, (Schl.) Tsch. Four-toed Salamander. Costal furrows well marked; skin of back cut so as to resemble scutæ; body short; limbs slender; tail rounded at base, compressed distally, one to two times length of body; color above brown, with irregular scattered black spots on sides; below whitish, with pitchy black spots; snout yellow; limbs and tail orange-brown; L. two and five-tenths inches. Rhode Island and Illinois to Gulf of Mexico.

Genus Plethodon, Tsch.

23. *P. cinereus*, subsp. *cinereus*, (Green) Cope. Palatine series of teeth well separated medially, not extending beyond inner nares externally; costal plicæ 16–19; form slender; tail cylindrical; limbs weak; inner toes rudimentary; above cinereous; no red dorsal band; below paler, sometimes spotted with darker; L. three and one-half inches. Eastern region.

24. *P. cinereus*, subsp. *erythronotus*, (Green) Cope. A red dorsal stripe from head to tip of tail; in other respects like preceding. Eastern region.

25. *P. cinereus*, subsp. *dorsalis*, Bd. M S S. Louisville, Kentucky; Salem, Massachusetts.

26. *P. glutinosus*, (Green) Bd. Viscid Salamander. Palatine series well separated medially, extending outside of inner nares; costal plicæ 14; form stout; tail rounded; limbs short, stout; inner digits distinct; black, usually with gray lateral blotches and smaller dorsal spots; L. four and one-half inches. Eastern and Austroriparian regions.

Genus Stereochilus, Cope.

27. *S. marginatum*, Hall. Costal folds 17; body elongate; width of head contained more than seven times in length to groin; tail compressed from base; finned; size small; pale-yellow with brown lines. Georgia.

Genus Manculus, Cope.

28. *M. remifer*, Cope. Tail stout, compressed; body shorter by length of femur; black, sides speckled with lighter. Florida.

29. *M. quadridigitatus*, (Holbrook) Cope. Tail slender, cylindrical; body longer, and muzzle broader than in preceding; color above, dirty yellow, with minute dark brown spots, sometimes forming lines on vertebral region; L. three and one-half inches. North Carolina to Florida.

Genus Spelerpes, Raf.

A. Palatine teeth not contiguous with sphenoidal patches, nor extending outward beyond nares; tail compressed; costal grooves 13–14.

30. *S. bilineatus*, Green. Two-striped Salamander. Costal plicæ 14, generally indistinct; tail not keeled proximally above, about length of body; median digits long; color yellow, with two longitudinal black lines, and sometimes a third, on vertebral region; abdomen unmarked; L. two and three-quarters inches. Eastern and Austroriparian regions, except Texas.

31. *S. longicaudus*, Green. Cave Salamander. Costal grooves 13; tail keeled above, about twice length of body; digits widely separated, moderate; yellow, with numerous irregular black spots scattered over sides and back; belly immaculate; L. five inches. Eastern and Austroriparian regions.

32. *S. guttolineatus*, Holb. Costal grooves 13; tail keeled above, longer than body, sometimes twice its length; inner digits longest; yellow with a dorsal and lateral black band; tail black, barred with yellow; belly mottled. North Carolina to *Mississippi*.

B. Palatine teeth contiguous posteriorly with sphenoidal patches, not extended outside of nares; tail rounded at base, not keeled; costal grooves 15–17.

33. *S. ruber*, subsp. *ruber*, (Daud.) Cope. Red Triton. Costal plicæ 15–16; tail not so long as body; color above, red with numerous, crowded, somewhat indistinct, black spots; abdomen paler, unspotted; iris with a dark longitudinal bar; L. six inches. Eastern and Austroriparian regions.

34. *S. ruber*, subsp. *montanus*, (Bd.) Cope. Costal plicæ 17; tail as long as body; above reddish-brown, with few, but well-defined, black or brown spots; beneath deep salmon-color; iris without dark bar; L. five inches. Alleghany Mountains, from Pennsylvania to South Carolina.

35. *S. ruber*, subsp. *sticticeps*, (Bd.) Cope. In M S S. South Carolina.

Genus Gyrinophilus, Cope.

36. *G. porphyriticus*, (Green) Cope. Purple Salamander. Costal plicae 14; width of head less than seven times to groin; canthus rostralis prominent; tail rounded at base, without fin; above yellowish-brown or salmon color, irregularly marked with gray; beneath whitish; L. six inches. Mountains, from Vermont to Alabama.

Family DESMOGNATHIDÆ.

Genus Desmognathus, Bd.

Premaxillaries united, embracing a fontanelle; parietals ossified; tongue free on sides and posteriorly; digits distinct, 4–5.

A. Costal plicæ 13–15.

37. *D. ochrophæa*, Cope. Generally a single, imperfect, lateral series of pores; no tubercle in canthus of eye; tail rounded, not finned; posterior half of mandible in males non-dentate; costal plicæ 13; brown, with a yellowish dorsal band; back dotted; belly dirty white, immaculate; males darker; L. three inches. Mountains, from New York to Georgia.

38. *D. fuscus*, subsp. *fuscus*, (Raf.) Cope. Generally two lateral series of pores, inferior, well developed, superior, irregular, or wanting; a tubercle in canthus of eye; tail compressed and keeled; mandible in males completely toothed; above brown, marked with gray and pink; belly marbled, the pale color predominating; no red spots on sides; L. three inches. Massachusetts to Mississippi; *Illinois.*

39. *D. fusca*, subsp. *auriculata*, (Holb.) Cope. Above black, with a series of small red spots on sides; belly marbled, the darker color predominating; otherwise as in preceding. South Carolina to Louisiana.

B. Costal plicæ 12.

40. *D. nigra*, (Green) Bd. Two well developed lateral series of pores; a tubercle in canthus of eye; tail flattened, attenuated, finned above; mandible in males completely toothed;

black above and below; L. six inches. Mountains, southward from Pennsylvania; *N. Illinois.*

Family PLEURODELIDÆ.

Genus DIEMYCTYLUS, Rafin.

Palatine teeth in two longitudinal series, diverging behind; tongue attached, lateral margin alone slightly free; ribs rudimentary; tail small, compressed from base; toes four in front, five behind, the inner and outer rudimentary.

41. *D. miniatus*, subsp. *miniatus*, (Raf.) Cope. Red Eft. Above red; sides with a row of large vermilion spots; beneath paler or yellowish, with numerous black dots; skin rougher than the following; terrestial; L. three and one-half inches. Eastern and Austroriparian regions.

42. *D. miniatus*, subsp. *viridescens*, (Raf.) Cope. Spotted Triton. Above olive-green, varying in shade, with a pale dorsal streak; beneath lemon-yellow; other markings as in the preceding; dorsal crest more developed; aquatic. Eastern and Austroriparian regions.

Order ANURA.

SYNOPSIS OF SUB-ORDERS AND FAMILIES.

A. Toothless.

a. Epicoracoid* divergent from coracoid, and connected with it by a longitudinal cartilaginous arch which is free from, but overlaps corresponding arch on opposite side.
Sub-order *Bufoniformia.*

Superior plate of ethmoid ossified; sacral diapophyses dilated; coccyx attached to two condyles; tongue free posteriorly .... *Bufonidæ.*

b. Epicoracoids, when present, in contact with coracoids; the distal ends of the former separated from those of the latter by articular cartilage only.
Sub-order *Firmisternia.*

Epicoracoids wanting; sacrum and coccyx not confluent; sacral diapophyses dilated... *Engystomidæ.*

B. Teeth on upper jaw.

a. Epicoracoids directed forward, divergent from coracoids, and connected with them by overlapping cartileges.
Sub-order *Arcifera.*

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*The precoracoid and acromial of some authors.

x. Coccyx and sacrum articulated by two condyles.
Sacral diapophyses dilated; vertebræ procœlian; terminal phalanges articulated inferiorly to penultimate, swollen at base, distal portion slender, nail-like; abdomen areolate .... *Hylidæ*.
Sacral diapophyses cylindrical; vertebræ procœlian; mandible toothless; terminal phalanges not as in preceding .... *Cystignathidæ*.
y. Coccyx and sacrum confluent; sacral diapophyses dilated; vertebræ procœlian; terminal phalanges continuous, conical .... *Scaphiopidæ*.
b. Epicoracoids in contact with coracoids, not connected with them by overlapping cartilages.
Sub-order *Raniformia*.
Sacral diapophyses cylindrical; xiphisternum and manubrium osseous; ear well developed; fronto-parietals never embracing fontanelle... *Ranidæ*.

ARTIFICIAL SYNOPSIS OF FAMILIES.

A. Toothless.
a. Parotoid glands present; tympanic membrane visible; skin more or less warty.................... *Bufonidæ*.
b. No parotoid glands; tympanic membrane concealed; skin smooth .... *Engystomidæ*.
B. Teeth on upper jaw.
a. Parotoid present; a large, flat-edged spur on heel.
Scaphiopidæ.
b. No parotoids or large spur on heel.
x. Terminal phalanges dilated; external metatarsi bound together.
abdomen granulated; terminal phalanges swollen at base and with slender, nail-like ends.. *Hylidæ*.
2. Abdomen smooth; terminal phalanges swollen at end and terminating in a viscous disk.
Cystignathidæ.
y. Terminal phalanges continuous; external metatarsi separated by a web.................. *Ranidæ*.

Sub-order BUFONIFORMIA.

Family BUFONIDÆ.

Genus BUFO, Laurenti.

Ear perfectly developed; prefrontals in contact with each other and with the fronto-parietals, the latter entirely osseous;

parotoids not confluent, rounded; two metatarsal tubercles; tongue oval, elongated; toes more or less palmated; skin tuberculous; no dorsal ossification on head; subgular vocal vesicle in males.

43. *B. lentiginosus*, subsp. *americanus*, LeConte. Common Toad. Superciliary ridges well marked, though but moderately elevated and not terminating in a knob posteriorly; skin on head thick, adhering to skull; tympanum well developed; parotoids large, sub-reniform; internal metatarsal tubercle large and spade-shaped; toes semipalmated; large tubercles on back; beneath granulated; color above, greenish or yellowish-brown, with scattered black spots or patches; two black patches under eyes, and occasionally spots about nostrils and jaws; beneath dirty yellowish, sometimes spotted and blotched; L. two and one-half inches. Eastern United States; west to the plains.

44. *B. lentiginosus*, subsp. *lentiginosus*, Latr. Superciliary ridges much elevated posteriorly and terminating in a rounded knob; mouth very large; tympanum and parotoid well developed, the latter uniform; toes semipalmate; back warty; abdomen granulated; above dusky brown, tinged with yellowish, and more or less blotched; beneath dirty yellowish-white; L. two inches. Austroriparian region.

45. *B. lentiginosus*, subsp. *fowleri*, Putnam, MSS. Massachusetts to Lake Winnipeg.

46. *B. quercicus*, Holb. Superciliary ridges slightly elevated, terminating posteriorly in a small knob; snout pointed; tympanum small; parotoids large, oblong; metatarsal tubercles small; toes slightly webbed; back with a few small warts; beneath granulated; body greatly depressed; back dusky, with a pale yellow vertebral line, on each side of which are black blotches, with here and there a tinge of reddish-brown; beneath silver-gray, with a yellowish tinge around vent; L. three-quarters of an inch. Florida to North Carolina and Louisiana.

47. *B. valliceps*, Wieg. Upper surface of head deeply concave; skin thin, firmly adhering to skull; superciliary ridges prominent; tympanum large; parotoids small; toes semipalmate; above yellowish-brown, with a broad dorsal streak of same tint, on each side of which is generally a black bar, extending the whole length of body; sides maculated; beneath unicolor in adults, spotted in young. Texas district and Louisiana.

Order FIRMISTERNIA.

Family ENGYSTOMIDÆ.

Genus Engystoma, Fitzinger.

Ethmoid arch ossified; prefrontals in contact with each other, and with the completely ossified fronto-parietals; terminal phalanges simple; ear fully developed; head small, not distinct from body; tympanic membrane concealed; toes free or slightly palmate; metatarsi with small tubercles.

48. *E. carolinense*, Holb. Head short, pointed; body thick, nearly oval; skin smooth; toes unwebbed; above chestnut, darker along vertebral line; below grayish, thickly sprinkled with black specks; L. one inch. Austroriparian region.

Order ARCIFERA.

Family HYLIDÆ.

No postorbital process to fronto-parietals, which embrace a large fontanelle; xiphisternum deeply emarginate; pupil horizontal; vomerine teeth present; true pollex a simple metacarpal, without phalanges.

A. Digital dilations small.

a. Toes broadly webbed; tongue extensively free, deeply notched behind.................. *Acris.*

b. Toes free; superior plate of ethmoid osseous; prefrontals separate................. *Chorophilus.*

B. Digital dilations well developed; tongue completely attached or one-third free; posterior digits webbed; vomerine teeth in transverse or posteriorly convergent fasciculi..... *Hyla.*

Genus Acris, D. et B.

49. *A. gryllus*, subsp. *gryllus*, LeConte. Head elongated; snout pointed; tympanum rather indistinct; hind legs very long; inner and hind part of thighs reticulated; body above, brownish or cinereous; middle of head and back green or reddish-brown; a triangular dark patch between eyes; a white line from orbit to arm; two or three large oblique dark patches, usually margined with white on sides; these markings sometimes wanting; beneath white, often varied with dusky; chin and throat tinged with yellowish; L. one and one-half inches. Austroriparian region.

50. *A. gryllus*, subsp. *crepitans*, Bd. Head rather obtuse; inferior surface of thigh plain; general appearance of the pre-

ceding; L. one and one-half inches. Eastern and central regions.

Genus Chorophilus, Bd.

51. *C. triseriatus*, Wied. Above light-bluish ash; a dark dorsal stripe, commencing at snout and bifurcating about middle of body; a stripe on each side of this, and one on the side of head and body, the latter edged with white below; abdomen whitish; L. one inch. Eastern and central regions.

52. *C. triseriatus*, subsp. *corporalis*, Cope, MSS. New Jersey.

53. *C. nigritus*, LeConte. Above olive-brown, tinged with yellow and speckled with small, white granulations; an interrupted vertebral line from snout to rump; upper lip white, above which is an irregular dark patch, extending from near snout to shoulder; head and extremities ash color, the latter with dusky bars; abdomen yellowish-white; L. one and one-half inches. South Carolina and Georgia.

54. *C. angulatus*, Cope. Above chestnut-brown or bronzed; upper lip white, above which is a black patch that passes near and terminates beyond shoulder; abdomen yellowish-white; L. one inch. South Carolina.

55. *C. ocularis*, Daud. Above uniform olive; a black streak from snout to shoulder; an oval blotch on sides; two or three small spots on loin. South Carolina to Georgia.

56. *C. ornatus*, Holb. Above dove-color with several oblong, dark brown blotches, margined with yellow, on each side of vertebral line; a black vitta from snout to near shoulder, and one from shoulder towards lower jaw; most of upper jaw yellowish; limbs with dark bands; anterior and posterior surface of thigh with yellow spots; beneath white; throat with a few black spots; under surface of legs flesh-color; L. one and one-fourth inches. South Carolina and Georgia.

Genus Hyla, Laurenti.

57. *H. andersoni*, Bd. Above rather deep pea-green; paler on sides and on margin of upper jaw; a narrow band of purplish-brown from eye to a little beyond insertion of arm; sides margined below by large, irregular spots of saffron; similar spots on a ground of paler shade before and behind humerus and femur, and beneath tibia; a band of mulberry tint on tibia anteriorly; beneath whitish flesh color; an oval spot of green on each side of throat; L. one inch, eight lines; femur eight

lines; tibia nine lines; foot twelve and one-half lines. New Jersey to South Carolina.

58. *H. squirella*, Daud. Above olive-green, with irregular dark blotches; a dusky bar between orbits; an indistinct band from nostril to eye; a white line along upper jaw to shoulder; beneath greenish-white in front, darker behind; throat with a few dark spots; extremities obscurely marked with darker above, flesh-colored beneath; L. one and one-quarter inches; thigh eight-tenths of an inch; leg eight-tenths of an inch; tarsus and toes nine-tenths of an inch. Austroriparian region.

59. *H. carolinensis*, Penn. Above bright green with occasional golden spots; a pale yellow line on sides of body; also one on posterior border of arm, and before and behind leg; limbs not barred; beneath yellowish-white; thigh yellow; leg flesh color; L. one and three-quarters inches; thigh eight lines; leg eight and one-half lines; tarsus and toes one inch, two lines. Austroriparian region.

60. *H. pickeringi*, Holb. Above yellowish-brown or fawn-color, with dusky spots and lines, the latter usually forming an oblique-angled cross on back; a line on top of head, extending back at an angle; another from nose to arm; limbs transversely barred, the dusky markings frequently very indistinct; beneath whitish; L. eleven and one-half lines; femur five and one-half lines; tarsus and toes nine and one-half; tibia five and one-half. Eastern region.

61. *H. femoralis*, Daud. Above cinereous, with large dark blotches; a triangular patch between eyes; six or eight sub-triangular spots of bright yellow on posterior surface of thighs, arranged nearly in a line; beneath white; chin sometimes marked with dusky; limbs with dusky spots or bars; color above somewhat variable, the darker markings not always present; L. one and one-half inches. Eastern part of Austro-riparian region.

62. *H. versicolor*, LeConte. Common Tree Toad. Above gray, greenish, or brown, with large, irregular dark blotches; below white; posterior part of abdomen yellow; skin above with minute warts and granulations; exceedingly variable; L. two inches; femur one inch; tibia nine-tenths; foot one and four-tenths. Eastern and Austroriparian regions.

63. *H. gratiosa*, LeConte. Above varying from bright green to cinereous or greenish-dusky, with roundish spots or irregular blotches of darker, or speckled with variously shaped spots of the same; a few small yellow spots on back and sides;

upper lip white, sometimes varied with green or dusky; in some specimens a line extends from jaw along sides, in others, the sides are variegated with rounded spots of darker, and the line is absent; beneath whitish, more or less inclining to yellow or orange; chin marked with dusky or green; limbs barred; yellowish or reddish beneath; skin coarsely granulate above; L. two and five-tenths inches; femur one and two-tenths inches; tibia one and fifteen-hundredths; foot one and six-tenths. Florida; lower Georgia.

Family CYSTIGNATHIDÆ.

Genus Lithodytes, Cope.

Prefrontals in contact, and usually with the fully ossified fronto-parietals; ear fully developed; xiphisternum broad, without style; external metatarsi bound together; digits nearly or quite free; terminal phalanges with a distal transverse limb, supporting a viscous disk; abdomen smooth.

64. *L. ricordi*, D. et B. Southern Florida.

Family SCAPHIOPIDÆ.

Genus Scaphiopus, Holb.

Tympanum, cavity of tympani, parotid glands, and vomerine teeth present; derm involved in cephalic ossification, which is complete; cuneiform bone furnished with a spade-like process which is covered with a corneous sheath; xiphisternum cartilaginous; toes more or less webbed.

65. *S. holbrooki*, Harl. Above brownish; a yellowish or pale ashy band on each side, sometimes indistinct; a vertical light line on end of muzzle, and two longitudinal streaks sometimes present; occasionally a pale interorbital crossband and light markings on sides; head large; maxillary rounded; eyes prominent; tympanum distinct; tongue large, emarginate; vomerine teeth opposite posterior border of internal nares; parotids small, prominent; a gland on each side of thorax, near axillæ; skin of back minutely tuberculous; of sides, more coarsely; below nearly smooth; cuneiform process very long; size moderate. Eastern United States.

Order RANIFORMIA.

Family RANIDÆ.

Genus Rana, Linn.

Vomerine teeth present; external metatarsi webbed to the base; terminal phalanges elongated, acute, or slightly dilated at tip; dorso-lateral dermal folds present or absent; abdomen smooth.

66. *R. areolata*, subsp. *capito*, LeConte. Above dark slate color, speckled with black; six rows of roundish spots on back, speckled and irregularly marked with spots of same form and color on sides; beneath yellowish-white, spotted and varied with dusky; arms and legs above gray, speckled and barred with black; beneath yellowish, especially at axillæ and groins; spotted and varied with dusky; head very large, broad, and blunt; coarsely punctured above; a deep concavity between nostril and eye; a broad, cutaneous fold from orbits to beyond middle of body; a second from corner of mouth to shoulder; body above very rough; posterior surface of thighs granulate; fingers slightly palmate at base; L. four and two-tenths inches; width of head at corners of mouth, one and five-tenths; arm one and nine-tenths; leg four and seventy-five hundredths; femur one and one-tenth; tibia one and forty-five hundredths; foot two and two-tenths inches. Florida.

Prof. Cope recognizes a second subspecies, *R. areolata areolata*, whose habitat is the Texan district, the following description of which is taken from the Mexican Boundary Survey: "Head very large, subelliptical; snout prominent, nostril situated half way between its tips and the anterior rim of eyes, which are proportionally large; tympanum spherical and of medium size; its central portion yellowish-white, whilst its periphery is black; body short and stout; limbs well developed; fingers and toes very long, without being slender; ground color of body, and head yellowish-green, marked with brown; besides there are thirty or forty brown areolæ." In our manuscript notes we had described a Rana from Benton Co., Indiana, as a new species. It differed so much from the description of *R. areolata areolata* and *R. areolata capito*, that we felt justified in giving it a new name provisionally until other specimens could be obtained so as to decide more definitely its relationship, if there was any specific, with *R. areolata*. An abstract of the following description was published in the second edition of Jordan's Manual of Vertebrata, under the name of *R. circulosa*.

Since then, other specimens have been examined and carefully compared with some from Florida and Texas. These have convinced us that specific differences do not exist between them. By comparing the description with those above, it will be seen, however, to differ as widely from them as they do from each other; therefore, if they can be retained as subspecies, the specimens falling under the following description will naturally form a third subspecies for which we propose to retain the name formerly used specifically, that is, *circulosa*.

67. *R. areolata*, subsp. *circulosa.* Above brownish-black, divided by very narrow lines of clay-color into circular and irregular blotches, which are largest posteriorly; arms with dark blotches; legs with transverse bars; posterior face of thighs mottled; beneath white; a few black spots along jaws; head broad, depressed; snout very obtuse, not produced; skin coarsely punctate above; a deep concavity between nostril and eye; diameter of tympanum and length of eye the same; internal nares oblique; the vomerine patches of teeth arranged obliquely between them; region above and behind tympanum much swollen; a broad, cutaneous fold on sides of back, narrower behind; a similar one from eye to arms; a third between these posteriorly; large oval tubercles on sides; hind surface and posterior half of under surface of thighs coarsely granulate; fingers distinctly webbed at base; toes palmated only between first phalanges, the webs narrow and incised; L. three and forty-six hundredths inches; femur one and forty-two hundredths; tibia one and sixty-three hundredths; foot two and forty-five hundredths; arms one and eighty-five hundredths; width of head one and thirty-two hundredths; length of leg five and five-tenths inches. Description taken from an alcoholic specimen collected in Benton Co., Indiana, by Mr. E. F. Shipman.

In the collection of the Smithsonian Institution, there are specimens bearing the specific name of *R. areolata* from Illinois (2), Texas (1), Florida (1), and Georgia (1). Those from Illinois, Florida, and Georgia have been labeled *R. areolata capito*, the other *R. areolata areolata.* The specimens from Illinois (northern portion) are in coloration like the one we have described above from Indiana, under the name of *R. areolata circulosa.* The Texas specimen is white below, above light brown with dark brown blotches, rounded on front portion of body and encircled by a narrow whitish line, more angular posteriorly; otherwise as in *R. areolata circulosa.* The Florida specimen is white below and yellowish or greenish above, and covered with rounded and more or less irregular brown spots;

otherwise as in *R. areolata capito.* The Georgia specimen is plain brown above; below thickly and finely mottled with brown and white; otherwise as in the last. The measurements of these are as follows:

	Length.	Width Head.	Arm.	Femur.	Tibia.	Foot.
N. Illinois.......	2.00 in.	.75 in.	.98 in.	.68 in.	.87 in.	1.31 in.
N. Illinois.......	1.87 "	.68 "	.93 "	.87 "	.97 "	1.25 "
Florida.........	2.12 "	.90 "	1.24 "	1.00 "	1.06 "	1.50 "
Georgia.........	2.55 "	1.05 "	1.20 "	1.25 "	1.37 "	1.87 "
Texas	3.12 "	1.06 "	1.60 "	1.50 "	1.55 "	2.25 "

68. *R. halecina*, Kalm. Common Frog. Above greenish, often bright, with distinct pale-edged dark blotches; a whitish line on sides of head; legs barred; beneath white or yellowish, occasionally dusky markings on throat; head rather elongated; tympanum moderate; a glandular fold along upper jaw and a well marked one on each side of back; generally a pair of ridges on coccyx; femur less than tibia; the latter more than one-half length of head and body; toes moderately webbed; L. two and three-quarters inches. North America.

69. *R. palustris*, LeConte. Pickerel Frog. Above pale brown, with two rows of large oblong square blotches of dark brown on back, one or two on sides; spots in the same row sometimes confluent; a brown spot above orbits; one near snout; a dark line from nostril to eye; upper jaw white, spotted with black; arms with dark blotches; legs with transverse bars above; posterior surface of thighs mottled; beneath yellowish-white; head short, rather obtuse; body slender; tympanum moderate; glandular folds depressed, inconspicuous; toes well palmated; L. two and three-quarters inches; femur about equal to tibia, and one-half total length. Eastern region.

70. *R. septentrionalis*, Bd. Above brown or olive, with vermiculations of lighter; sometimes a few dark blotches posteriorly; beneath white or yellowish, unblotched; a cutaneous fold on each side of back; femur and tibia about equal, and about one-half length of body; L. two and one-half inches. Canada to Montana.

71. *R. clamitans*, Merrem. Green Frog. Above green or brownish, darker posteriorly; generally with irregularly disposed small blackish spots; arms with dark blotches; legs with narrow transverse bars; beneath white, sometimes tinged with yellow, and frequently marked with dusky in front; posterior surface of thighs mottled with black; tympanum large; an elevated cutaneous fold on each side of back; toes well palmated; femur

and tibia about equal, and one-half length of body; L. three inches. Eastern United States.

72. *R. catesbiana*, Schaw. Bull Frog. Above greenish of varying shades, marked with numerous small dark spots; head usually bright, pale green; extremities blotched; posterior surface of thighs mottled with blackish; below yellowish-white, often clouded with dusky; cutaneous folds none or inconspicuous; head very large, as broad as long; tympanum large; interval between patches of palatine teeth comparatively large; toes broadly webbed to the base of last joint; femur about equal to tibia, and less than one-half total length; L. five inches. Eastern United States.

73. *R. temporaria*, subsp. *sylvatica*, LeConte. Wood Frog. Above pale reddish-brown; a dark brown vitta, narrow before and broad behind, from snout to near shoulder, bordered below by a yellowish white line; a black spot usually at base of arms; flanks mottled in front; extremities with transverse dark bars above; below white, sometimes mottled on anterior surface; head small, pointed; tympanum small; a narrow cutaneous fold on each side of back; femur and tibia about equal, the latter considerably more than one-half total length; L. one and three-eighths inches. Eastern region.

74. *R. temporaria*, subsp. *cantabrigensis*, Bd. General appearance and size of preceding; light colored lateral folds and a dorsal line from snout to arms; sometimes dark spots above; a narrow light line along posterior face of thighs; tibia about one-half length of body. Canada to Rocky Mountains.

REPTILIA.

SYNOPSIS OF ORDERS.

A. Cloacal aperture transverse; penis double; dorsal vertebræ movable upon one another and ribs upon them; teeth present; lungs free; limbs when fully developed, with free digits; heart trilocular.

a. Rami of lower jaw loosely united in front by ligament and muscle, attached behind to a movable quadrate bone, which in turn is connected with a movable squamosal; palatine united to pterygoid only; no pectoral arch or urinary bladder; no eyelids or tympanic cavity. . . . . *Ophidia.*

b. Rami of jaw more firmly united; no movable squamosal; anterior ends of palatines united to maxillæ and vomers; pectoral arch and urinary bladder present; usually with movable eyelids and a tympanic cavity. *Lacertilia.*

B. Cloacal aperture round or longitudinal; penis simple.

a. A dorsal shield or carapace present, composed of the much-flattened spinous processes of the dorsal vertebræ, and the greatly expanded ribs, which are united to superficial bony plates; ribs and dorsal vertebræ immovable; all vertebræ without transverse processes; an abdominal plate or plastron; pectoral and pelvic arches within shield; scapula and precoracoid anchylosed; quadrate firmly united to skull; heart trilocular; lungs fixed against inner periosteum of carapace; no true teeth; urinary bladder present. . . . . . *Testudinata.*

b. No carapace or plastron; anterior dorsal vertebræ with elongated and divided transverse processes; teeth in sockets; lungs free; four well-developed limbs; heart quadrilocular; rami of lower jaw united by suture; quadrate immovably fixed to skull; no urinary bladder; movable eyelids, and rudimentary external ear. *Crocodilia.*

Order OPHIDIA.

Synopsis of Families.

A. Maxillary bone vertical; fangs erectile, perforated, and not grooved externally; a deep fossa on each side of head behind nostril, partly occupying the excavated maxillary. . . . . *Crotalidæ*.

B. Maxillary bone horizontal, not excavated; rudimentary extremities none.

x. Maxillary with a permanently erect, perforated, and usually grooved tooth; neural spines and pleurapophyses short; caudal hypopophyses bifid. *Elapidæ*.

y. Maxillary produced to premaxillary, bearing solid teeth; coronoid bone wanting. . . . . *Colubridæ*.

Artificial Synopsis of Families.

A. Sub-caudal scutellæ entire; head very distinct from body. *Crotalidæ*.

B. Sub-caudal scutellæ bifid.

x. Postorbitals wanting; head continuous with body. *Elapidæ*.

y. Postorbitals present; head variable . . . . . *Colubridæ*.

Family CROTALIDÆ.

A. Top of head scaled; tail terminated in a rattle. *Crotalus*.

B. Top of head covered with symmetrical plates.

a. Tail terminated in rattles . . . . *Caudisona*.

b. Tail terminated in a horny point . . . . . . *Ancistrodon*.

Genus Crotalus, Linn.

1. *C. horridus*, Linn. Northern Rattlesnake. Muzzle covered above with small plates or numerous scales; two marginal shields between superciliary and rostral; rostral high, narrow, cuneiform; scales 23–25 rows, all carinate; 12–14 labials; two rows of scales between them and the orbit; a light line from superciliary plate to angle of mouth; on body two series of brown dorsal rhombs, which are confluent, except on the anterior part, forming transverse zigzag blotches; tail black; general color sulphur-brown of various shades; G. 165–170. Eastern and Austroriparian regions.

2. *C. adamanteus*, subsp. *adamanteus*, (Beauv.) Cope. Diamond Rattlesnake. Muzzle, marginal shields, and rostral,

the same as in the preceding species; dorsal rows 27; 14–16 labials; three rows of scales between suborbitals and labials; general color brown; three series of complete brown rhombs with yellow edges, the median row largest and separated only by their yellow margins; a yellow line from superciliary to angle of mouth; G. 165–170, North Carolina to Florida; Mississippi.

Genus CAUDISONA, Laur.

3. *C. miliaria*, Linn. Ground Rattlesnake. Color above dark grayish ash; a series of 38 or 45 dark brown dorsal blotches, with a narrow yellowish border; a broad dorsal band of brownish-red passing through these from head to tail; three series of blotches on each side; a white line from lowest part of orbit extending back obliquely to angle of mouth; below reddish-yellow, marmorated with blackish blotches and minute dots; dorsal rows 22–25, all carinated; G. 130–140. Austroriparian and Sonoran regions.

4. *C. tergemina*, (Say) Cope. Massassauga. Color above brown; about thirty-four deep chestnut-brown dorsal blotches; blackish externally, and with yellowish-white margins; three lateral series of blotches; a narrow band of yellowish-white from the pit to neck; below blackish-brown and yellowish; color above sometimes uniform black; dorsal rows 25, all carinated except the outer one; G. 135–150. Eastern region west of Alleghany Mountains; Georgia.

Genus ANCISTRODON, Beauv.

5. *A. piscivorus*, subsp. *piscivorus*, Lac. Water Moccasin. No loral plate; two pairs of occipitals; upper wall of pit formed by anti-orbital; third labial large, constituting the inferior wall of orbit; general color brown, with 20 or 30 indistinct dark vertical bars, one or two scales wide; beneath black with yellowish-white blotches; an obsolete brown streak behind eye; dorsal rows 21–25; G. 138–145. Austroriparian region, except Texas.

6. *A. atrofuscus*, Troost. Black Moccasin. Above dusky with rhomboidal smoky-gray dorsal blotches, disappearing near the black tail; beneath white, blotched with black and minutely punctate; upper lip white; dorsal rows 25; G. 130–140. Mountains of Tennessee and North Carolina.

7. *A. contortrix*, Linn. Copper Head; Cotton Mouth. Loral present; suborbital plates present; one pair of occipital

plates; posterior wall of pit formed by anteorbital; general color hazel-brown, brightest on top of head; on sides 15–26 dark blotches, somewhat resembling an inverted Y; sides of head yellowish-white; chin and throat unspotted; beneath dull yellowish, with a series of 35–45 large dark blotches on each side; dorsal rows 22–23; G. 150–155. Eastern and Austroriparian regions.

Family ELAPIDÆ.

Genus Elaps, Schu.

Body slender; tail short; head somewhat depressed, generally continuous with body; scales smooth; anal entire; subcaudal bifid; nasals two; loral none; anteorbital one; postorbitals two.

8. *E. fulvius*, subsp. *fulvius*, Linn. Harlequin Snake. Head black anteriorly with a yellow ring across the occipital region; body annulated with alternating red and black rings, 14–19 of each, which are separated from one another by a narrow band of yellow; the black rings covering about eight scales, the red six, and the yellow one or two; tail with alternate rings of black and yellow; colors beneath the same, but duller; the red spaces spotted with black; dorsal rows 15; G. 205–210. Austroriparian region.

9. *E. distans*, Kenn. Body slender; annulated with alternating black and reddish rings, which are not separated by lighter ones; the black rings are narrow on the body, four or five scales wide, and are broad upon the tail, about eight scales wide; the plain, unspotted, reddish rings of the back, three or four times as wide as the black ones; on the tail, only a third or fourth as wide; dorsal scales small. Florida.

Family COLUBRIDÆ.

Artificial Synopsis of Genera.

A. Dorsal scales smooth; anal divided.
a. Nasals one.
1. Prefrontal one.......................6. *Farancia.*
2. Prefrontals two or none.
x. Anteorbital absent.
†Postorbital one; unicolor........1. *Carphophiops.*
‡Postorbitals two; striped.............5. *Abastor.*

y. Anteorbitals present.
†Superciliaries small, narrow, width nearly uniform; eye small............................7. *Contia.*
‡Superciliaries quite large, broadest posteriorly; eye large.............................13. *Cyclophis.*
b. Nasals two.
1. Loral absent..........................4. *Tantilla.*
2. Loral present.
x. Anteorbitals present.
†One anteorbital.
*Dorsal rows 17..................12. *Dromicus.*
**Dorsal rows 25 to 29.............14. *Coluber.*
‡Two anteorbitals.
*Head depressed; anteorbitals nearly equal in size..........................11. *Diadophis.*
**Head deep; upper anteorbital much the largest. 17. *Bascanium.*
y. Anteorbitals absent.................2. *Virginia.*
B. Dorsal scales smooth; anal entire.
a. Loral absent..............................9. *Osceola.*
b. Loral present.
1. Rostral acute, produced forwards, causing a sharply pointed snout.......................8. *Cemophora.*
2. Rostral not produced.
x. Superciliaries moderate; scales scarcely overlapping; head depressed....................10. *Ophibolus.*
y. Superciliaries broad; scales imbricate; head deep. 15. *Spilotes.*
C. All or part of dorsal scales carinate; anal entire.
a. Postfrontals two pairs..................16. *Pityophis.*
b. Postfrontals one pair....................18. *Eutænia.*
D. All or part of dorsal scales carinate; anal divided.
a. Nasals two.
1. Rostral produced, recurved and keeled.23. *Heterodon.*
2. Rostral not produced.
x. One prefrontal.........................3. *Haldea.*
y. Two prefrontals.
†Loral present.
*Scales on back slightly carinate; sides smooth; G. 200–235.....................14. *Coluber.*
**All dorsal scales carinate; G. 130–170. 21. *Tropidonotus.*
‡Loral absent.........................19. *Storeria.*

b. Nasal one.

1. Two prefrontals; two postorbitals.

x. Nasal not grooved below nostril; tail very long. 13. *Cyclophis.*

y. Nasal grooved; tail short.....20. *Tropidoclonium.*

2. One prefrontal; three postorbitals......22. *Helicops.*

1. Genus Carphophiops, Gerv.

Prefrontals present or absent; nasal one; orbit formed anteriorly by loral and postfrontal; postfrontal one; superciliaries very small; vertical broad; dorsal scales smooth; anal divided. head continuous with body; unicolor.

a. One pair of frontal plates.

10. *C. helenæ*, Kenn. Snout shorter and narrower than in the following species. Color above lustrous chestnut brown; beneath flesh color, which extends to second row of lateral scales; dorsal rows 13. Southern Illinois and Mississippi.

b. Two pair of frontal plates.

11. *C. amœnus*, Say. Ground Snake. Color above chestnut brown; yellowish or salmon color beneath; dorsal rows 13; G. 120–130. Massachusetts to Louisiana and Illinois.

12. *C. vermis*, Kenn. Worm Snake. Color above lustrous, purplish black; beneath flesh color, extending to third row of lateral scales; dorsal rows 13. Larger than the preceding species. Missouri, Kansas, and Southern Illinois.

2. Genus Virginia, B. and G.

Nasals two, nostril in the anterior one; loral and postorbital forming anterior border of orbit; postorbitals two; vertical broad; dorsal scales smooth; anal divided; eye moderate; head distinct from body.

13. *V. valeriæ*, B. and G. Color above yellowish or grayish brown, with minute black dots irregularly scattered or constituting rows; beneath yellowish; subrhomboidal dorsal scales in 15 rows; G. 120–130. Maryland to Illinois, and North Carolina.

14. *V. elegans*, Kenn. Color above uniform light olive-brown; beneath dull yellowish-white; dorsal scales very narrow and elongated, in 17 rows. Southern Illinois and Arkansas.

3. Genus Haldea, B. and G.

Prefrontal one; nasals two; loral and postfrontal forming anterior part of orbit; postorbital one; superciliaries large; verti-

cal hexagonal, elongate; dorsal scales carinate, in 17 rows; anal divided; G. 120–130; eye large; head distinct from slender body; unicolor above.

15. *H. striatula*, (Linn) B. and G. Above reddish-gray; below salmon color; G. 125–130. Virginia to Texas; *Illinois* (Ridgway).

4. Genus Tantilla, B. and G.

Nasals two; loral absent; anteorbital one; posterior one or two; dorsal scales smooth; anal divided; eyes small; head continuous with body; unicolor.

16. *T. coronata*, B. and G. One anteorbital; two postorbitals; color above reddish-brown; head a deep chestnut-brown; a black band across neck above, in front of which is a narrow lighter space; dorsal rows 15; G. 140–145. Georgia and Mississippi.

5. Genus Abastor, Gray.

Nasal one, grooved beneath nostril; loral and postorbital forming anterior part of orbit; postorbitals two; vertical elongated; dorsal scales smooth; anal divided; eyes moderate; head continuous with body.

17. *A. erythrogrammus*, (Daud.) Gray. Red-lined Snake. Color above bluish-black, with three longitudinal lines of red (yellow in alcoholic specimens); median line narrowest; beneath flesh color, with two series of bluish-black blotches; dorsal rows 19; G. 175–185. North Carolina to Alabama; *Illinois.*

6. Genus Farancia, Gray.

Prefrontal one; nasal one; loral and postfrontal form anterior part of orbit; postorbitals two; dorsal scales smooth; anal divided; eye small; head slightly distinct from body.

18. *F. abacura*, (Holb.) B. and G. Red-billed Horn Snake. Color above bluish-black, with sub-quadrate red spots on the flanks; beneath red, barred and blotched with black; dorsal rows 19; G. 170–175. Austroriparian region.

7. Genus Contia, B. and G.

Nasal one; loral present; anteorbital one; postorbitals two or one; superciliaries small, narrow; width nearly uniform; vertical broad; dorsal scales smooth; anal divided; eye small; head short, depressed.

19. *C. pygæa*, Cope. Postorbitals two; color above black, with faint pale lines along the center of each scale on several lateral rows; beneath yellowish; tail reddish; dorsal rows 17; G. 118–122. Florida.

8. Genus Cemophora, Cope.

Dentition isodont; rostral acute, produced forward, causing a sharply pointed snout; nasals one or two; loral one; anteorbital one; postorbitals two; superciliaries small; dorsal scales smooth; anal entire; eye small; head subconical, continuous with body.

20. *C. coccinea*, Blumenbach. Superciliaries very narrow; upper labials six; body yellowish-red (crimson in life), crossed by from 20 to 26 black rings, enclosing yellow ones; beneath uniform yellowish-white; dorsal rows 19; G. 160–170. Austroriparian region.

9. Genus Osceola, B. and G.

Nasals two; loral absent; postfrontals very large, touching upper labials; anteorbital one; postorbitals two; dorsal scales smooth; anal entire; eye large; head distinct from slender body.

21. *O. elapsoidea*, (Holb.) B. and G. Scarlet Snake. Postorbital large, and extending to second upper labial; rostral very broad; ground color bright red, fading beneath, annulated by about 18 pairs of jet black rings, each enclosing a white one; the black rings tapering on the sides, the white ones widening; head red, maculated with black; a yellow collar on upper part of neck, bordered by black lines; dorsal rows 19; G. 175–180. Virginia to Florida; *Illinois*.

10. Genus Ophibolus, B. and G.

Nasals two; loral present; anteorbital one; postorbitals two; superciliaries moderate; dorsal scales smooth, scarcely overlapping; anal entire; head depressed; body rather thick; tail short; eyes small.

A. Dorsal rows 21.

a. Predominating color black.

22. *O. getulus*, subsp. *getulus*, (Linn.) Cope. Chain Snake. A series of large black blotches along middle of back, and another on each side; these are separated from one another by narrow, continuous, yellow lines; abdomen with central black blotches, which are usually confluent with those on sides; G. 210–225. East of Alleghanies, from Maryland to Florida and Louisiana.

23. *O. getulus*, var. *sayi*, (Holb.) Cope. King Snake. Above black, with a yellow spot in the center of each scale; these spots sometimes form interrupted transverse lines across the back; the scales between with indistinct or obsolete spots; abdomen yellowish white with black blotches; G. 210–225. From Alleghany to Rocky Mountains, north to Illinois; *Wisconsin* (Hoy.)

b. Predominating color not black.

24. *O. doliatus*, subsp. *doliatus*, (Linn.) Cope. Corn Snake. Color red (in alcohol, yellowish); back crossed by pairs of narrow black lines, between which are yellow ones; the lines of each pair separate on sides and become confluent with the nearest one of the adjacent pair; abdomen varied irregularly with black; G. 190–215. Maryland to Kansas; Illinois, Arkansas, Louisiana, and Texas.

25. *O. doliatus*, subsp. *coccineus*, (Schl.) Cope. Red Snake. The same as last, except that the black lines are not confluent with those adjacent, but form black rings extending around the body, the ends of which sometimes meet on the abdomen and sometimes not; G. 180–210. Florida to New Mexico; Kansas; *Illinois*.

26. *O. doliatus*, subsp. *triangulus*, (Boie.) Cope. Milk Snake. Color above grayish ash, with a dorsal series of about fifty chocolate blotches and two other series on each side. The dorsal ones about four scales long and 12–15 wide, separated by intervals of one and one-half to two scales; beneath yellowish-white, with square black blotches; G. 200–215. Virginia to Canada; Iowa and Wisconsin.

27. *O. rhombomaculatus*, Holb. Color above light chestnut, with a dorsal and two lateral series of darker rhomboidal blotches; the dorsal ones, about fifty in number, one and one-half to two and one-half scales long, six or seven wide, and separated by intervals of about three scales; beneath reddish-yellow, obscurely blotched with light brown; G. 200–205. North Carolina, Georgia, *Illinois*.

B. Dorsal rows 25.

28. *O. calligaster*, Say. Above light olivaceous brown or gray, with a dorsal series of about 60 subquadrangular, emarginate, dark chestnut-brown blotches from head to tip of tail; two smaller lateral series on each side. Illinois to Kansas and Arkansas.

11. Genus Diadophis, B and G.

Nasals two; loral present; postorbitals two; anteorbitals two, rarely equal in size; dorsal scales smooth, anal divided; eye large; head depressed; unicolor, with generally a light ring on the occipital region.

A. Dorsal rows 15.

29. *D. punctatus*, subsp. *punctatus*, (Linn.) Cope. Ring-necked Snake. Eye over fourth and fifth upper labials; body above bluish-black; beneath yellowish-orange, with a series of sub-triangular spots along sides of scutellæ, and sometimes a similar medial series; tail beneath unicolor; eight upper labials and chin yellowish; a yellowish-white occipital ring, about two scales wide; G. 140–160. United States and Canada, east of the plains, and Texas.

30. *D. punctatus*, subsp. *amabilis*, (B. and G.) Cope. Eye over third and fourth upper labials; above blackish-brown; beneath yellowish-white, with crowded small black spots from head to end of tail; the seven upper labials and chin blackish-brown; occipital ring narrow; scales on sides considerably larger than those on back; G. 180–185. Western United States, east to Ohio.

B. Dorsal rows 17.

31. *D. arnyi*, Kenn. Color above uniform leaden-black; beneath yellow, spotted thickly and irregularly with black; the spots on under part of neck smaller; occipital ring light yellow, narrow, one and two half scales wide. Illinois and Kansas.

12. Genus Dromicus, Bibron.

Posterior maxillary tooth largest, not grooved, separated by an interspace from the rest; nasals two; loral rarely wanting; postorbitals two; dorsal scales rather short, rarely slightly carinate; generally in 17 or 19, exceptionally in 15 or 23 rows; anal divided; eye moderate.

32. *D. flavilatus*, Cope. Nostril in the prenasal; color above golden brown; the two lower rows of scales gold-edged; color of back commencing on the third row of scales; vertebral row sometimes darker tipped; below whitish; dorsal rows 17; G. 126. Coast of North Carolina.

13. Genus Cyclophis, Günther.

Teeth equal, smooth; snout protruding; loral one, occasionally wanting; postorbitals two; dorsal scales smooth or carinate; anal divided; eye large.

33. *C. vernalis*, DeKay. Summer Snake. Color above green; below yellowish; tail between one-third and one-fourth total length; dorsal rows 15, all smooth; G. 130–140. Eastern and Austroriparian regions.

34. *C. æstivus*, (Linn.) Günther. Grass Snake. Color above bright green; below yellowish-white; tail more than one-third of total length; dorsal rows 17, the vertebral ones strongly keeled; G. 150–160. Austroriparian region, north to New Jersey and Southern Illinois.

14. Genus Coluber, Linn.

Nasals two; loral present; anteorbitals one; postorbitals two; dorsal scales slightly carinate along back, smooth on sides (the carinations sometimes obsolete); anal divided.

A. Without longitudinal brown bands.

a. Scales in 29 rows.

35. *C. emoryi*, (B. and G.) Cope. Vertical longer than head; color above ashy-gray, with a dorsal series of transverse brown blotches, and two smaller lateral rows (sometimes traces of a third); dorsal blotches narrowly margined with black; beneath yellowish-white, with indistinct brownish blotches; ten or twelve outer rows of dorsal scales smooth, the rest slightly carinated; G. 210–220. Mississippi Valley to Kansas and Illinois.

36. *C. lindheimeri*, B. and G. Vertical as broad as long; a series of black dorsal and lateral blotches; intermediate spaces lighter; scales edged with white; beneath greenish-white; bluish slate color on centers of scutellæ, especially posteriorly; dorsal scales obsoletely carinated; outer ten rows smooth; G. 225–235. Texas, Arkansas, and Southern Illinois.

b. Scales in 25 rows; vertical broader than long.

37. *C. vulpinus*, B. and G. Fox Snake. Color above light brown, with about 60 transverse, quadrate, chocolate dorsal blotches, margined with black; one or two lateral rows of same color; dorsal blotches three or four scales long; beneath yellowish-white, with alternating quadrate black blotches; the four lateral rows of scales smooth; G. 200–210. Massachusetts to Kansas, and northward.

c. Scales in 25–27 rows; vertical longer than broad.

38. *C. obsoletus*, subsp. *obsoletus*, (Say.) Cope. Pilot Snake. Color above uniform black; a few scales narrowly edged with white; beneath slaty-black, except on the chin and

throat, which are yellowish; dorsal rows 27, the seven outer smooth; G. 230–235. Eastern United States from Texas to Massachusetts.

39. *C. obsoletus*, subsp. *confinis*, B. and G. Color above ashy-gray, with a series of about 45 dark chocolate-brown dorsal blotches, with indistinct black margins; blotches six or seven scales long and eleven wide; two smaller lateral series; beneath yellowish, blotched with black; dorsal rows 25, outer six smooth, the rest obsoletely carinated; G. 235–240. Austroriparian region to Missouri; *S. Illinois.*

40. *C. guttatus*, Linn. Color above light red, paler on sides, with a series of about 45 dark brick-red quadrate dorsal blotches, deeply margined with black; two more or less distinct series of similar lateral blotches. In some alcoholic specimens the blotches are hazel, with lighter intervals; beneath yellowish-white, with sub-quadrate black blotches; dorsal rows 27, very obsoletely carinated; G. 215–235. Austroriparian region to Virginia; *S. Illinois.*

B. With four longitudinal brown bands.

41. *C. quadrivittatus*, Holb. Chicken Snake. Color above greenish-yellow, with a brown lateral and dorsal band on each side; beneath light straw color; dorsal rows 27, only five or eight median ones carinated; G. 230–240. North Carolina to Florida.

15. Genus Spilotes, Wagler.

Nasals two; loral one, sometimes two; anteorbitals one or two; postorbitals two; superciliaries very broad; dorsal scales smooth, slightly carinate along the back in some foreign species; anal entire; head deep.

42. *S. couperi*, Holb. Postorbitals over the fourth labial; color above black; beneath dark slate; no red markings on abdomen; G. 185–187. Georgia.

43. *S. erebennus*, Cope. Postorbitals over the fifth labial; color above black, with scattered spots of reddish-white at base of the scales; beneath slate color, anteriorly with bases of scutellæ red; G. about 195. Texas to Alabama.

16. Genus Pityophis, Holb.

Vertical elongated, sometimes absent; posterior frontals two pairs; loral one; anteorbitals one or two; postorbitals three or four; dorsal scales carinate along back, smooth on sides; anal entire.

44. *P. melanoleucus*, Daud. Pine Snake. Bull Snake. Anteorbital one; postorbitals three; color above whitish, with a dorsal series of brown blotches, margined with black, 24 to the anus; three series of lateral blotches which are more or less confluent; dorsal scales in 29 rows, the four outer ones smooth, the next three obscurely carinate; G. 220–230. New Jersey to South Carolina, Ohio, *Michigan* (Gibbs).

45. *P. sayi*, subsp. *sayi*, Schl. Western Pine Snake. Anteorbital one; postorbitals three; color above chestnut-brown, with numerous transverse reddish-orange blotches, which form bands posteriorly; sides mottled with black and orange; dorsal scales in 25 rows; G. 220–225. Illinois to Kansas and northward.

17. Genus Bascanium, B. and G.

Nasals two; loral present; anteorbitals two, upper much the larger; postorbitals two; dorsal scales smooth; anal divided; eye very large; head narrow, deep; body slender.

46. *B. constrictor*, Linn. Center of eye over fourth labial, which alone is in contact with postorbital; color above in adult, pitch-black; beneath with greenish tinge; young with dorsal blotches; dorsal rows 17; G. 175–190. Austroriparian and Eastern regions.

47. *B. anthicum*, Cope. Eye over third and fourth or fourth and fifth labials; color above black, varied with many yellow scales which are either single or grouped in irregular spots; beneath yellow; dorsal rows 17. Louisiana.

48. *B. flagelliforme*, Catesb. Center of eye over junction of fourth and fifth labials, the last in contact with the postorbital; color above black anteriorly and brownish posteriorly, lightest on tail; beneath yellowish-white, blotched with brown anteriorly; dorsal rows 17; G. 200–210. South Carolina to Florida.

18. Genus Eutænia, B. and G.

Nasals two; loral present; anteorbitals one or two; postorbitals three or four; dorsal scales carinate; anal entire; general color three light stripes on a dark ground.

A. Lateral stripe on third and fourth rows of scales.

a. Scales little or not spotted, in 19 rows.

x. Dorsal band complete.

*Stripes uniform in color.

49. *E. saurita*, (Linn.) B. and G. Riband Snake. Color above bright chocolate; light brown below, lateral stripes;

beneath greenish-white; tail more than three and less than three and one-quarter times in total length; G. 150–160. Austroriparian and Eastern regions.

50. *E. faireyi*, B. and G. Garter Snake. Color above blackish-brown; beneath greenish-white; color above and below lateral lines the same; tail less than one-third total length; G. 165–180. Mississippi Valley from Louisiana to Wisconsin.

**Stripes not uniform in color.

51. *E. proxima*, (Say.) B. and G. Color above black; dorsal stripe ochraceous yellow or brown; lateral ones greenish-white or yellow; light below lateral lines; beneath greenish-white and yellowish; tail three and one-half or more times in total length; G. 165–180. Mississippi Valley north to Wisconsin; Texas and Northern Mexico.

y. Dorsal band incomplete or wanting; all scales keeled.

52. *E. sackeni*, Kenn. Color above olive-black; not lighter below the very narrow greenish-yellow lateral stripes; beneath uniform greenish; tail one-third total length. Floridan district.

b. Scales above and below lateral line with sub-quadrate black spots.

53. *E. radix*, B and G. Hoy's Garter Snake. Color above varying from deep brownish-black to olive-green; with three narrow gamboge-yellow stripes; six series of black spots, sometimes obscure; below greenish with black markings predominating on sides; tail about five times in total length; superior labials seven; dorsal scales rough, in 19–31 rows; G. 150–160. Central region to Lake Michigan; Oregon.

B. Lateral stripe on second and third rows of scales.

a. Scales in 21 rows.

54. *E. vagrans*, B. and G. Color above ashy or brown, with dorsal stripe on a single row of scales, sometimes wanting; on each side about 100 small black spots in two series; beneath plumbeous or slate color; superior labials eight; G. 160–180. Central, Pacific, and Northern regions; *Illinois* (Nelson).

b. Scales in 19 rows.

x. A dorsal band.

55. *E. sirtalis*, subsp. *sirtalis*, (Linn.) Cope. Common Garter Snake. Color above olivaceous-brown, three series of small spots on each side, about 70 from head to anus; the upper series encroaching on the narrow and rather indistinct dorsal stripe; greenish-white below the lateral lines and on abdomen;

G. 135–160. Entire North America, except Sonoran region and along Pacific coast.

56. *E. sirtalis*, subsp. *parietalis*, (Say.) Cope. Color above olive-brown; two series of quadrate black blotches on sides, between which are blotches of brick-red; beneath bluish-green; G. 155–160. Central and Pacific regions; Indiana and Illinois.

57. *E. sirtalis*, subsp. *obscura*, Cope. Color above uniform brown; spots obscure; dorsal and lateral bands distinct. Eastern sub-region north of Washington; northern part of Pacific region.

58. *E. sirtalis*, subsp. *dorsalis*, (B. and G.) Cope. Color above olivaceous, with three broad greenish-white stripes; below lateral ones and on abdomen greenish-white; two rows of small spots on each side, the superior row connected by a narrow line; upper labials seven or eight; G. 160–170. Entire North America.

y. No dorsal band.

59. *E. sirtalis*, subsp. *ordinata*, (Linn.) Cope. Color above olive, with three distinct rows of dark square spots, about 85 from head to anus; lateral and dorsal stripes very indistinct or wanting; beneath greenish-white, with black spots on sides of scuttelæ; G. 135–155. Northern part of Eastern region and North Alabama.

19. Genus Storeria, B. and G.

Nasals two; loral absent; anteorbitals one or two; postorbitals two; dorsal scales carinate; anal divided; head distinct from small body; general color brown, with two dotted dorsal lines.

60. *S. dekayi*, (Holb.) B. and G. DeKay's Brown Snake. Color above gray or chestnut-brown, with a clay-colored dorsal band; a series of dots along its margin, two scales apart; two other dotted lines and traces of a third on sides; a dark patch on each side of the occipital; beneath grayish-white; one ante and two postorbitals; dorsal rows 17; G. 120–140. Central, Austroriparian and Eastern regions.

61. *S. occipitomaculata*, (Storer.) B. and G. Red-bellied Snake. Color above gray or chestnut-brown, with sometimes a paler vertebral line, margined by a series of black dots; three light blotches on base of head; beneath red or salmon-color; two anterior and posterior orbitals; dorsal rows 15; G. 115–130. Eastern region; South Carolina and Georgia.

20. Genus Tropidoclonium, Cope.

Nasal one; grooved below nostril; loral present; anteorbital one; postorbitals two; dorsal scales carinate; anal divided.

62. *T. kirtlandi*, (Kenn.) Cope. Kirtland's Snake. Body stout; head small, continuous with neck; tail short and small; ground color light reddish-brown, with four dorsal series of circular black spots, the two central series smallest; beneath uniform reddish, with a row of small black spots on each side; dorsal rows 19; G. 130–140. Illinois to Ohio.

21. Genus Tropidonotus, Kuhl.

Nasals two; loral present; anteorbitals one or two; postorbitals two or three; all dorsal scales carinate, except occasionally one or two outer rows; anal divided.

A. Five or more longitudinal bands on a light ground.

63. *T. grahami*, B and G. Anteorbitals two; postorbitals three, lower very small; a light brown dorsal band, on each side of which is a narrow black band, three scales below is a second black line, and between the abdomen and sides a third; above the second line the scales are brown, below it straw color; beneath yellowish, with a blackish band under tail; dorsal rows 20, all carinate; G. 160–165. Mississippi Valley to Wisconsin; Michigan.

64. *T. leberis*, Linn. Anteorbitals two, upper larger; post two, upper smaller; color above chestnut or chocolate-brown; a black band on median row of scales, another on the fifth, and a broader yellow band on the first and second; beneath yellowish, with two brown bands; dorsal rows 19, all carinated. Austroriparian and Eastern regions.

65. *T. rigidus*, Say. Anteorbitals two, upper larger; post two, nearly equal in size; color above greenish-brown, with a deeper brown spot at base of each scale on the flanks; two brown bands on back; beneath dull yellowish, with two series of brown blotches; dorsal rows 19, two outer obsoletely or not at all carinated. Pennsylvania to Georgia, east of the Alleghanies.

B. Unicolor or transversely barred or blotched.

x. No suborbital plates.

Dorsal rows 19, all carinated.

66. *T. compsolæmus*, Cope. Postorbitals three, lower very small; color above blackish-brown, with indistinct pale transverse bands, two or three scales apart; beneath a stone-brown, generally

darkest in the center; a yellow spot near anterior border of each of the anterior gastrosteges; G. 125–130. Florida.

Dorsal rows 21, all carinated.

67. *T. compressicaudus*, Kenn. Body much compressed near tail; postorbitals three, upper and lower small, middle one with lower border produced to labials; color above yellowish-olive; four black stripes on neck; body anteriorly crossed by zigzag black bars, posteriorly with three series of spots, not alternating. Florida.

68. *T. ustus*, Cope. Nostril in the prenasal plate; postorbitals two; color above yellowish ferruginous, palest on the head and darkest on the tail; anteriorly are indistinct half bands; posteriorly the bands cross the back completely; beneath salmon colored; G. 125–130. Florida.

Dorsal rows 23–25.

69. *T. fasciatus*, Linn. Postorbitals two or three; color above blackish-brown, with transverse black dorsal blotches, and about 35 sub-triangular or oblong red spots on the flanks; sometimes broken rings of yellow dots across back; beneath reddish-white, sometimes blotched with black; G. 128–135. Austroriparian regions.

70. *T. sipedon*, subsp. *sipedon*, Linn. Postorbitals three; color above brownish, with three series of alternating dark blotches bordered with black, more or less confluent, especially anteriorly, about 30 from head to tail; the light intervals sometimes obsolete; beneath yellowish blotched with brown; G. 135–145. Eastern and Austroriparian regions, except Texas.

71. *T. sipedon*, subsp. *woodhousei*, B. and G. Color above dusky, with three series of black blotches, about 40 in number; a narrow whitish line between the dorsal blotches; beneath yellowish, sometimes spotted with black; G. 140–150. Texas to Missouri; *Illinois*.

72. *T. sipedon*, subsp. *erythrogaster*, Shaw. Postorbitals three; dorsal scales very strongly keeled on posterior part of body; color above uniform reddish (black in alcohol), and beneath copper color; G. 148–155. Austroriparian region, except Texas; Michigan, *Illinois*, Kansas.

Dorsal rows 29, all carinated.

73. *T. taxispilotus*, Holb. Postorbitals two; color above reddish-brown, with three series of subquadrangular blackish blotches, about 46 in number; the dorsal series seven to ten rows wide, and two to three scales long; the lateral series nine to ten

rows wide, and three to five scales long; beneath yellowish-white, with brown blotches; G. 140–145. North Carolina to Georgia.

Dorsal rows 27, all carinated.

74. *T. rhombifer*, Hallowell. Postorbitals two or three; color above light brown; about 50 dorsal blotches of same color, surrounded by black lines; beneath yellowish-white, blotched with darker; G. 140–145. Louisiana to Illinois and Michigan.

y. A suborbital series of plates; dorsal rows 29–31.

75. *T. cyclopium*, Dum. et Bib. Ante and postorbitals two; (in Cuban specimens, one anteorbital and only 23 dorsal rows); color above dark plumbeous brown, with blackish alternating vertical bars, one or one and one-half scales wide, and three and one-half or four scales apart; beneath brownish-white; G. 140–145. Florida; *S. Illinois*.

22. Genus Helicops, Wagler.

Teeth smooth, the posterior two in upper jaw longer than and separated from the others; prefrontals one or two; nostril not higher than wide; nasal grooved; loral sometimes absent; anteorbitals one or two; postorbitals two or three; temporals four to twelve; upper labials eight or nine; lower nine or eleven; dorsal scales carinate in 10 to 25 rows.

76. *H. alleni*, Garman. Head continuous with neck; one prefrontal; nasal plates meeting behind rostral; loral present; one ante and three postorbitals; color in longitudinal bands; the vertebral dark brown, five and two half scales wide; the next yellowish-brown, two half scales wide; the next dark brown, two and two half scales wide; the next brownish-yellow, two and one-half scales wide; beneath and on upper labials dull yellow or straw color; dorsal scales smooth, in 19 rows, exterior very wide; two vertebral rows of tail strongly keeled; G. 128. Florida.

23. Genus Heterodon, Beauv.

Posterior palatine teeth largest; rostral produced, recurved and keeled; behind rostral and between frontals one or more small plates; nasals two; loral one or two; orbit bordered below and on sides by a continuous chain of small plates; dorsal scales more or less carinate, smooth in some foreign species; anal divided; head broad and short; body stout; tail short; head, neck and body capable of great dilation.

A. Azygos in direct contact with frontals.

77. *H. platyrhinus*, (Latr.) Cope. Blowing Adder. Rostral prominent; scales on back of head carinate; center of eye

over fifth labial; color above yellowish or brownish, with darker dorsal blotches, 20 to 30 from head to anus; sides more or less mottled with dark blotches; occasionally uniform black above; dorsal rows 23–25; all, or all but two or three outer rows strongly keeled; G. 125–150. Austroriparian or Eastern regions.

78. *H. platyrhinus*, subsp. *atmodes*, (B. and G.) Cope. Rostral obtuse, but little prominent; scales on back of head obsoletely carinate; center of eye over fourth labial; color above pitch-black, with 25 light yellow transverse dorsal bands (sometimes nearly obsolete); sides mottled with black and yellowish; beneath yellowish, blotched with black; young specimens somewhat lighter; dorsal rows 23; the scales with short keels, the outer rows obsoletely carinate; G. 130–145. North Carolina to Georgia.

B. Azygos encircled by from five to ten small plates.

79. *H. simus*, subsp. *simus*, (Linn.) Cope. Hog-nosed Snake. Vertical as broad as long; upper labials high, seven to eight; ground color above light brownish-yellow, with a dorsal series of about 35 transverse black blotches; on sides from one to three smaller series; beneath yellowish, obscurely maculate; dorsal rows 25, outer ones smooth; G. 115–135. Austroriparian region, except Texas; *Illinois and Wisconsin.*

Order LACERTILIA.

Synopsis of Families.

A. Vertebræ procœlian; parietal bone single.

a. Pterygoid in close contact with sphenoid.

Teeth simple, conical, and pointed, attached to the inner side of the jaws; tongue scaly; body covered by square equal shields; limbs usually absent; tail very short . . . . *Amphisbænidæ*.

b. Pterygoid not touching sphenoid.

x. Supranasal plates not more than one pair; clavicle with a dilated proximal end.

Premaxillary single; temporal fossæ not roofed; xiphisternal fontanelle present; tongue squamose or squamose-papillose; nostril either in a plate or suture . . . . *Teidæ*.

Premaxillary double; temporal fossæ roofed;

xiphisternal fontanelle rarely present; tongue squamose; nostril in a plate.......... *Scincidæ.*

y. Supranasal plates numerous; internasal plate large, transverse; head shielded behind; tongue papillose, sheathed at the tip; clavicle with a simple proximal end; mesosternum cruciform .... *Anguidæ.*

z. Tongue simple, papillose; clavicle with a simple, proximal end.

Articular bone and xiphisternal fontanelle wanting; abdominal ribs present .... *Anolidæ.*

Articular bone and, generally, xiphisternal fontanelle present; abdominal ribs rarely present. *Iguanidæ.*

B. Vertebræ usually amphicœlian; parietals double.

Pterygoid not touching sphenoid; tongue papillose. *Gecconidæ.*

ARTIFICIAL SYNOPSIS OF FAMILIES.

A. Limbs none.

Tongue scaly; eyes invisible.......... *Amphisbœnidæ.*

Tongue not scaly; eyes visible............ *Anguidæ.*

B. Limbs present.

x. Toes simple.

1. Tongue deeply bifid at end; scales of back small, granular.................................. *Teidæ.*
2. Tongue not deeply bifid.

Scales of back large, smooth.......... *Scincidæ.*

Scales of back large, carinate........ *Iguanidæ.*

y. Toes expanded into disks near the end.

Toes clawless; scales of back large, keeled. *Gecconidæ.*

Toes with claws; scales of back granular... *Anolidæ.*

Family AMPHISBÆNIDÆ.

Genus RHINEURA, Cope.

Nasal shields present; ten or twelve plates on head; no preanal pores; tail depressed, and tuberculous above; eyes invisible.

80. *R. floridana*, Baird. Floridan Blind Snake. Vertical plate large and irregularly pentagonal; occipitals small; three small plates on each side of vertical; nasal single; superior labials four; inferior three or four; sternal plates small, about 12; three pair of preanal plates in a longitudinal series; superior maxillary teeth 5–5, anterior pair longest; 14 to 16 rings on tail, all but

basal ones tuberculous; color dirty white; head yellowish above. Florida.

Family SCINCIDÆ.

Nasal plate single, ungrooved, nostril in the center; rostral erect, triangular; scales smooth; limbs present; toes compressed, five on each foot.

Palate toothless; supranasal plate none; lower eyelid with a transparent disk; ear large, circular, entirely exposed .... *Oligosoma.*
Palate toothed; supranasal plates two; lower eyelid scaly; limbs strong; ear dentate in front..... *Eumeces.*

Genus OLIGOSOMA, Grd.

81. *O. laterale*, (Say.) Grd. Ground Lizard. Head short; body and tail long; color above chestnut, with a black lateral line from snout to near tip of tail; beneath neck silvery-white; abdomen yellowish; tail blue; limbs weak. Austroriparian region; South Carolina.

Genus EUMECES, Wieg.

82. *E. septentrionalis*, (Bd.) Cope. Northern Skink. One postnasal plate, not separating the internasals and postfrontals; color above olive; with four equidistant and equal dark stripes, covering two half rows of scales; two narrow white lateral lines traversing the centers of a single row of scales, margined by black; upper lateral stripes separated by six rows of scales; beneath greenish. Minnesota, Nebraska, and *Wisconsin.* (Hoy.)

83. *E. egregius*, (Bd.) Cope. Floridan Skink. One postnasal plate, separating postfrontal and internasals; four upper labials; two central dorsal rows of scales largest; ear very small; color above reddish-ash, with two white lines on each side, margined with dusky; sometimes a third; each on the center of a single row of scales; upper lateral lines separated by two plain rows of scales. Florida.

84. *E. onocrepis*, Cope. Frontal in contact with vertical; postfrontals not in contact medially; superciliaries three, anterior longest; superior labials eight; dorsal scales equal; color above dark brown, darkest on sides and lightest on tail; two narrow light lines on each side of head and neck, none on body or tail; below white or straw color. Florida.

85. *E. anthracinus*, (Bd.) Cope. Coal Skink. Color above dark bronze, with four yellow lateral stripes, between and above

and below which are lines of anthracite black; the upper yellow line on the center of a single row of scales; the lower on parts of two rows; tail dark blue above; below yellowish-white. Pennsylvania to Texas, in mountains.

86. *E. obsoletus*, (B. and G.) Western Skink. Parieto-occipital and vertical the largest cephalic plates; color above greenish-white; the scales narrowly margined with black; beneath uniform. Sonoran region, borders of Central and Austroriparian, *Illinois* (Forbes).

87. *E. fasciatus*, (Linn.) Cope. Common Skink. Postnasals one or two, separating internasals and postfrontals; superciliaries five; superior labials eight; dorsal scales equal; color above bluish-black, or olive-brown, with five yellow lines, the median one forming two on the head; the superior lateral ones bordering the superciliaries; inferior lateral extending forward on superior labials; the median and superior lateral line on parts of two rows of scales; the inferior lateral on one and one-half or two rows before and just behind arms, but covering a single row on sides; the lines are two rows apart, and frequently partially or wholly absent. Head sometimes reddish. Below yellowish-white. Central, Austroriparian, and Eastern regions.

Family TEIDÆ.

Genus Cnemidophorus, Wieg.

Body slender; above covered with small, granular scales; below large ones; tail long, ringed with large, carinated scales; head long, narrow, pyramidal, covered with large regular shields; ear large; tongue long and slender, bifid at end; generally two gular folds; outer part of arms and legs covered with large shields.

88. *C. sexlineatus*, (L.) D. and B. Six-lined Lizard. Internasal none; superciliaries three, two large; color on head and along back dusky brown; on each side three yellow longitudinal lines, the upper one short, and somewhat indistinct; between these longitudinal lines jet black; throat silvery-white; abdomen bluish-white. Sonoran, Austroriparian regions to S. E. Virginia; *Illinois and Wisconsin.*

Family ANGUIDÆ.

Genus Opheosaurus, Daud.

Tongue arrow-headed in shape, with a triangular notch in front; anterior free part with granular papillæ; teeth in several

rows on the palate; nostrils lateral in a single plate; supra-nasal shields narrow and numerous; ear small; body serpentiform, with two deep lateral furrows; limbs none.

89. *O. ventralis*, Daud. Glass Snake. Markings somewhat variable, but generally yellowish on back, frequently with spots of brown or greenish; two narrow brown or black dorsal lines; sides brown, with two narrow longitudinal greenish lines, often spots of the same; below yellowish white. Austroriparian region; Kansas; *Illinois and Southern Wisconsin.*

Family IGUANIDÆ.

Genus Sceloporus, Wiegman.

Body depressed, covered with large, keeled scales; caudal and dorsal the same, except that those of the back are arranged in transversely diagonal series and those of tail in simple transverse; back not crested; sides not serrate; head without spines, the plates smooth, slightly convex; throat with a fold on each side; nostril superior, subapical; ear with a dentate fringe of scales in front; femoral pores distinct; toes simple.

90. *S. undulatus*, subsp. *undulatus*, Harl. Superciliaries in four rows, the two outer and the inner small; scales of back large, strongly carinate, about 35 oblique rows from head to base of tail; scales on inside of tibia not carinate; color variable; above greenish or bluish with transverse undulating dark bands; below yellowish, mottled with darker and usually a large blue or greenish blotch on throat and sides; length about seven inches. North America, except Sonoran and Lower Californian regions.

91. *S. floridanus*, Baird. Superciliaries in three rows, the inner and outer small, the middle large; scales of back large, rough, about 33 oblique rows from head to base of tail; scales on sides of tibia carinate; color above greenish-yellow, with two broad yellow stripes, five scales apart, and with distinct blackish transverse bars; larger than S. undulatus. Florida.

Family ANOLIDÆ.

Genus Anolis, Merrem.

Teeth on palatines; toes 5–5, long and slender; the penultimate joint in all except the inner ones, which are rudimentary, much expanded; hind limbs longer than the fore; scales of body small and rounded; skin on throat loose and more or less inflata-

ble: back with or without a crest; upper jaw rounded at end, even with the lower; rostral erect.

92. *A. principalis*, Linn. Green Lizard; Floridan Chameleon. Head pyramidal, broad and flattened; tail rounded and tapering, covered with imbricate scales, which are larger than those of the body; length more than one and one-half times that of head and body; color of head brown; of body above, varying through all shades from bright pea-green to bronze-brown; a lighter dorsal stripe; back and sides with fine brown zigzag lines; body below ashy, greenish, or soft white; loose skin on throat with longitudinal brown lines; sometimes scarlet; no crest. Austroriparian region.

Family GECCONIDÆ.

Genus Sphærodactylus, Cuv.

Scales of back equal, granular or rhombic; tail with a central series of shields; neither femoral nor preanal pores; eyelids circular. Toes with a single series of transverse plates beneath; clawless, with a terminal compressed point; free, slender, subcylindrical at base, with a small, entire, circular terminal disk, convex beneath.

93. *S. notatus*, Baird. Scales on back and sides large, strongly carinated, on belly smaller, smooth, hexagonal; above light brownish-yellow; dotted all over with reddish-brown, most distinctly on head and least on belly. Key West, Fla. (Cuba).

Order TESTUDINATA.

Synopsis of Families.

A. Forearm and hand, and leg and foot, in the form of wings or paddles; not capable of distinct movements at wrist and ankle joints; digits flattened, elongated, and bound immovably together by the integument.

a. Feet scaleless; the anterior pair very large; the posterior smaller but broad . . . . *Sphargididæ.*

b. Feet covered with scales. . . . . *Chelonidæ.*

B. Limbs not in the form of paddles, capable of distinct movements at wrist and ankle joints.

a. Shield leathery, incompletely ossified; feet with few scales; head long and pointed; body very flat. *Trionychidæ.*

b. Shield completely ossified.

x. Fingers and toes not bound closely together; more than the distal phalanges free.

*Tail crested, very long and strong; plastron narrow and small; bony vertebral plates 12, continuous the whole length of carapace; plates of plastron nine; head large; neck long and stout; body highest in front.. *Chelydridæ.*

**Tail short; plastron usually broad and large.

1. Lower jaw with a long, strong, sharp point at symphysis; bony vertebral plates from 5–7, not continuous; plates of plastron eight in adult; iliac bones arched outwards; coracoids reaching back of middle transverse suture of plastron; coracoid and pubis closely approximated; skin loose on knees and elbows; tail tipped with a horny spur in males. *Cinosternidæ.*

2. Lower jaw without long point at symphysis; bony vertebral plates 10, continuous; plates of plastron nine; iliac bones nearly parallel; coracoid not reaching middle transverse suture; skin clinging more or less to knees and elbows. *Emydidæ.*

y. Fingers and toes bound closely together; only the last joint free; bony vertebral plates about 10; plates of plastron nine; iliac bones wider apart at hip joints than at sacrum........... *Testudinidæ.*

Family SPHARGIDIDÆ.

Body highest in front and widest at the anterior edge of the bridge; posterior limbs much exposed; head high, short and very broad at the back; two pits and two teeth-like projections on the upper jaw; a single, median projection on the lower. There is but one genus in the family.

Genus Sphargis, Merrem.

Body covered by a smooth coriaceous skin; feet without nails; several longitudinal ridges along carapace.

94. *S. coriacea*, Rondelet. Leathery Turtle. Color above dark brown; below whitish; nodules along the longitudinal ridges of carapace. On the Atlantic coast to Massachusetts.

Family CHELONIDÆ.

Body highest in front, and widest about the middle; no tooth-like projections on the jaws; carapace heart-shaped.

A. Costal scales five on each side; scales around the large median plate on top of head 13 to 20; scales on cheeks 15 to 20; cutting edge of lower jaw not serrated.........*Thalassochelys.*

B. Costal scales four on each side; scales around large median plate on top of head seven.

- *a.* Scales on cheeks from 7 to 10; cutting edge of lower jaw not serrated.....................*Eretmochelys.*
- *b.* Large scales on cheeks 15 to 20; cutting edge of lower jaw deeply serrate.........................*Chelonia.*

Genus THALASSOCHELYS, Fitz.

95. *T. caouana*, Linn. Loggerhead Turtle. Head low, broad and flat; jaw with strong, pointed beaks; shell smooth, subcordiform; vertebral scales 5, costal 10, and marginal 25 to 27; scales not imbricate; two nails to each paddle. Entire Atlantic coast.

Genus ERETMOCHELYS, Fitz.

96. *E. imbricata*, Linn. Tortoise-shell Turtle. Head low and broad; anterior part of jaws produced forward into a projecting bill; scales on shield imbricated, forming thick, hard plates; four pairs of costals; no horny plates on neck; two nails to each paddle. Southern Atlantic coast.

Genus CHELONIA, Brong.

97. *C. mydas*, Schw. Green Turtle. Head high and narrow; upper jaw slightly notched in front; lower jaw with a small projection; the sides deeply serrated; body oblong; scales of shield thin, not imbricated; a single nail to each paddle. Atlantic coast, south of Long Island.

Family TRIONYCHIDÆ.

Head long and narrow; nostrils not subdivided by an internal ridge; edge of upper jaw sharp, and serrated behind. *Amyda.*

Head broad; nostrils subdivided by a ridge which projects from the median wall; edge of upper jaw not serrated. *Aspidonectes.*

Genus Amyda, Ag.

98. *A. mutica*, (Les.) Ag. Fresh-water Leather Turtle. Back depressed; no spines on anterior margin of carapace, and no tubercles on back. Color above, in adult, nearly plain olive; in young, more or less spotted with black; below whitish, without spots. North of the Ohio river, in tributaries to the Mississippi and St. Lawrence.

Genus Aspidonectes, Wag.

a. Lower surface of body and under part of feet white.

99. *A. ferox*, Schw. Soft-shelled Turtle. Tubercles on shield in male larger than in female; in the young, two or three concentric black lines, separating the pale margin from the light brown colored back, which is studded with black dots and ocellated spots, becoming blotched in the adult. Georgia to Western Louisiana.

b. Lower surface and under parts of feet spotted with black.

100. *A. spinifer*, Les. Common Soft-shelled Turtle. A blunt median keel, sloping uniformly on the sides; in the young, a single black line about the edge of the carapace; shield olive-brown, with dark spots; spines less prominent in males than in females. North of the Ohio river, in tributaries of the Mississippi and St. Lawrence.

101. *A. nuchalis*, Ag. Agassiz's Soft-shelled Turtle. Marked depressions on either side of the blunt median keel, which has a triangular dilation in front; spines and tubercles prominent in the male. Cumberland and Upper Tennessee rivers.

102. *A. asper*, Ag. Tubercles large and coarse, behind supported by prominent bony warts on the osseous plates; in the young, two or three black lines around the posterior part of the carapace. Tributaries of the Lower Mississippi.

Family CHELYDRIDÆ.

Head narrow about the nose and eyes, broad behind; feet strong, and toes with long, strong claws; web small.

a. Eyes lateral and distant; alveolar plate very broad; strong pointed projection at the symphysis of the jaws; three scales on each side between costal and marginal rows.................... *Macrochelys.*

b. Eyes superior, rather close together; alveolar plate narrow; a small pointed projection at symphysis of jaws; no scales between the costal and marginal rows .... *Chelydra.*

Genus Chelydra, Schw.

103. *C. serpentina*, Linn. Common Snapping Turtle. Head rough, covered with soft skin; tail with two rows of large scales beneath; ridges of carapace disappearing with age; jaws moderately hooked. Throughout the United States, except Pacific sub-region.

Genus Macrochelys, Gray.

104. *M. lacertina*, Schw. Alligator Snapper. Head very large, covered with smooth, symmetrical plates; tail with many small, imbricate scales beneath; carapace strongly tri-carinate; the keels not disappearing with age; jaws strongly hooked. South of Missouri river, in tributaries to the Mississippi and Gulf of Mexico; north to Wisconsin.* Rare.

Family CINOSTERNIDÆ.

Head pointed in front; eyes situated far forward; lower jaw terminating in a sharp point; limbs slender; feet short.

a. Plastron small, narrow behind, with eleven scales; front and hind portions very little, if at all, movable on middle.................... *Aromochelys.*

b. Plastron larger; front and hind portions broad and rounded, freely movable on middle part (except often in old specimens); scales 8 to 11. Alveolar plate flat and rather broad .... *Cinosternum.*

Genus Aromochelys, Gray.

105. *A. odoratus*, Latr. Musk Turtle. No point at symphysis of upper jaw; the end of lower curved somewhat upward and outward; scales of carapace not imbricated in adult; shell dusky, clouded, sometimes spotted; two yellow stripes, one above, the other below the eye, extending along the neck. Austroriparian and Eastern sub-regions.

106. *A. carinatus*, Gray. Little Musk Turtle. A point or chisel edge at symphysis of upper jaw; scales of keel somewhat

*Fide Dr. P. R. Hoy.

imbricated; edged with black, and with black lines or dots radiating from their posterior portion to their front and lower margins; no stripes along neck. Louisianian district; *Northern Illinois.*

Genus Cinosternum, Wagl.

107. *C. pennsylvanicum*, Bosc. Mud Turtle. Jaws strong, and hooked in front; scales smooth; color above dusky-brown; below variable, yellowish to chestnut; head dark, with light dots; throat yellowish. Austroriparian and Eastern sub-regions.

Family EMYDIDÆ.

A. Plastron and carapace immovably united by a bony symphysis; no hinge across middle of plastron.

- *a*. Alveolar surface of jaws broad.
  1. Alveolar surface of upper jaw with a submedian ridge, parallel to margin; toes short and strongly webbed; head with thin, hard skin; upper jaw notched in front....... *Pseudemys.*
  2. Alveolar surface of jaws smooth; in front part of upper a deep groove; toes short; head covered with soft skin; upper jaw not notched in front .... *Malacoclemys.*
- *b*. Alveolar surface narrow.
  1. Alveolar groove well marked, except in front; toes strong, broadly webbed and spreading; hind feet largest; carapace rather flat. *Chrysemys.*
  2. Carapace considerably arched; toes with a small web; feet nearly equal in size; species small. *Chelopus.*

B. Plastron and carapace united by a cartilaginous lateral suture; plastron hinged across the middle.

- *a*. Carapace somewhat depressed; plastron more or less emarginate behind; feet strongly webbed... *Emys.*
- *b*. Body short and high; plastron rounded or truncate in front and behind; feet nearly free of webs. *Cistudo.*

Genus Pseudemys, Gray.

A. No scales upon loose skin between legs; ridge on alveolar surface of upper jaw tuberculate; shield in young covered

with more or less confluent ocellated or lozenge-shaped figures, which become more transverse in adult, and may wholly disappear in old age.

a. Strong, coarse serratures on both jaws; prominent hooks at symphysis of upper.

108. *P. rugosa*, Shaw. Red-bellied Turtle. Above dusky with variable markings; generally with irregular bands or blotches of red; below dusky or reddish; head and neck brown, with obscure reddish lines. New Jersey to Virginia.

109. *P. mobilensis*, Holb. Above brown, reticulated with yellow lines; below yellow, more or less blotched with black; head and neck brown, with yellow, longitudinal lines; serratures of lower jaw coarser than in upper. Florida to Texas.

b. Lower jaw alone distinctly serrated; upper comparatively smooth; notch at its symphysis small.

110. *P. concinna*, LeC. Above brown, with yellowish lines, which are mostly longitudinal on vertebral row of scales, transverse or bifurcating on the costal, and concentric or transverse on marginal; below yellow; neck with yellow or reddish lines. Austroriparian region.

c. Both jaws smooth.

111. *P. hieroglyphica*, Holb. Hieroglyphic Turtle. Above olive-brown, subdivided into spaces of various shapes, by more or less concentric yellow lines; below dusky yellow; head and neck dark brown with yellow lines. Middle, Western, and Gulf States.

B. Scales upon loose skin between legs and on neck; low ridge on alveolar surface of upper jaw not tuberculate; vertebral scales, with numerous longitudinal bands; costal scales with transverse ones; marginal scales with concentric figures; in old age the bands disappear; edge of marginal plates notched.

112. *P. scabra*, Linn. Rough Terrapin. Above dark brown, with irregular and broken bands of yellow; head and neck black, with yellow lines; throat with broader lines; carapace broad, high, keeled, and covered with coarse rugosities; deeply serrated behind. North Carolina to Georgia.

113. *P. troosti*, Holb. Yellow-bellied Terrapin. Above dusky, with a greenish tinge, and slightly mottled; below brownish-yellow, more or less blotched with black; head and neck obscurely banded with yellowish lines; carapace not keeled, and with but slight rugosities. Valley of Mississippi to Illinois.

114. *P. elegans*, Wied. Above brown, more or less marked with irregular lines of yellow or brownish-yellow; below yellow, with dark blotches; head and neck dusky, with bright red or yellowish lines on sides and beneath; carapace smooth and flat. Central region; Texan district; *Southern Illinois.*

Genus Malacoclemys, Gray.

a. A spoon-shaped dilation at extremity of lower jaw.

115. *M. geographicus*, Les. Map Turtle. Above olive-brown, with paler streaks and intersecting lines, which are especially distinct on neck, legs, and edge of carapace; plastron yellowish; carapace sometimes well keeled; the vertebral row of scales not imbricated. Mississippi Valley, Pennsylvania, and New York.

116. *M. pseudogeographicus*, Holb. Above as in last, but with the markings less distinct and of large figure; yellow stripes on head, neck, and legs; plastron yellow, with black or reddish-brown markings; carapace keeled; vertebral row of scales more or less imbricated by a black projection on their posterior border. Mississippi Valley to Wisconsin and Northern Ohio.

b. No spoon-shaped dilation on lower jaw.

117. *M. palustris*, Gmel. Diamond Back. Carapace sometimes a plain greenish-gray, sometimes almost black, and sometimes with concentric stripes; plastron varying from light yellow to yellowish-green or reddish-brown; plain or dotted, or concentrically striped; shell smooth or with concentric grooves. Coast from New York to Texas.

Genus Chrysemys, Gray.

118. *C. picta*, Herm. Painted Turtle. Body rather flat; bridge connecting carapace and plastron wide but flat; scales of carapace greenish-black, edged with a paler tint; marginal scales with bright red markings; plastron yellowish, generally blotched. Eastern region, Louisiana and Misissippi.

119. *C. reticulata*, Bosc. Southern Painted Turtle. Body moderately high and elongated; bridge high and wide; plastron somewhat narrow; above dusky or dark brown, reticulate with yellow lines, which are frequently obscure in adult specimens; beneath yellow, sometimes with black markings. Gulf States.

Genus Chelopus, Raf.

a. Edge of upper jaw straight, slightly notched in front, but not produced downward.

120. *C. guttatus*, Schw. Speckled Tortoise. Snout rounded, and its sides not compressed laterally; above black with yellow spots; rarely plain black; plastron black, or yellow spotted with black. Eastern region, east of Ohio.

b. Upper jaw more or less deeply notched in front, and projecting in the form of an arched bill.

121. *C. muhlenbergi*, Schw. Sides of head compressed, but not narrowing downward; carapace with or without a keel, and the scales either plain or concentrically grooved; a large tooth on either side of notch in upper jaw; above dark brown, obscurely blotched with lighter; neck with a dark orange blotch on each side; below dark with yellowish or reddish spots. New Jersey and Eastern Pennsylvania.

122. *C. insculptus*, LeC. Wood Turtle. Sides of head compressed, and nose narrowing downward; in the adult the scales either have radiating ridges, or are smooth; above reddish-brown, with radiating black lines; plastron yellow with black blotches; throat and extremities reddish. Eastern region, east of Ohio.

Genus Emys, Brong.

123. *E. meleagris*, Shaw. Blanding's Tortoise. Black, usually with yellow spots on the carapace; head spotted; plastron yellow with black blotches; young nearly circular, and entirely black except the plastron, which is edged with white. Alleghanian district to Wisconsin.

Genus Cistudo, Flem.

Vertebral scales about as wide as long; the young, and often the adult, with a distinct keel.

124. *C. clausa*, subsp. *clausa*, Gm. Box Turtle. Shell broad; colors variable; above blackish with yellow blotches, or numerous small spots and lines; sometimes the background appears yellow with black markings; beneath usually blackish, with a yellow border, occasionally all yellow; hind feet with four toes.* Eastern part of United States.

125. *C. clausa*. subsp. *triunguis*, Ag. Three-toed Box Turtle. Three toes on hind feet; color pale yellowish, with few spots. Austroriparian region to Georgia, Eastern Pennsylvania.

*A number of specimens from Pease River, Florida, collected by Dr. J. W. Velie, and a considerable number in the National Museum, from Lake Okeechobee, agree in the following distinguishing characters, and may represent a local Floridan variety:

Carapace more arched than in the last; costal plates flatter, and sloping abruptly downward; marginal plates flaring but little; shell narrower and higher; color above blackish; a yellow dorsal line; vertebral scales with a few lines of yellow; on the costal scales the lines are few and long, radiating from the posterior upper corner; beneath yellowish, with generally small scattered black spots and streaks; scales of carapace, in small specimens, somewhat imbricated.

Family TESTUDINIDÆ.

Genus Testudo, Linn.

126. *T. Carolina*, Linn. Gopher Turtle. Above brownish; head almost black; beneath yellow; fore limbs large and strong; hind ones short and rounded; plastron projecting beyond the carapace in front. Austroriparian region.

Order CROCODILIA.

Family CROCODILIDÆ.

Head depressed, elongated; nostrils approximated at end of muzzle; tongue fleshy, adherent; teeth in a single row; body depressed; with solid, carinated shields on back; tail compressed laterally; presacral vertebræ procœlian.

Nasals entering into formation of nasal aperture; teeth unequal.

a. Muzzle broad; sides of head subparallel; forehead divided longitudinally by a ridge; fourth pair of mandibular teeth received in pits in sides of upper jaw. *Alligator.*

b. Muzzle narrow, head tapering; fourth pair of mandibular teeth received into grooves in edges of upper jaw. *Crocodilus.*

Genus Alligator, Cuv.

127. *A. mississippiensis*, Daud. Common Alligator. Nuchal plates four, separate from cervical; on back eight longitudinal series of quadrilateral and strongly tuberculo-carinated plates; flanks covered by nine or ten rows of smaller, smooth, rhomboidal plates; beneath, the smooth square plates are arranged in transverse and longitudinal rows; above dusky brown or black in adult; in young barred with yellow; beneath yellowish, somewhat dusky. Austroriparian region.

Genus Crocodilus, Cuv.

128. *C. americanus*, Seba. Floridan Crocodile. Muzzle elongated; nuchal plates four to two; cervicals six; dorsal plates in four longitudinal series; vertebral large, regular, broader than long; lateral series scattered, irregularly hexagonal; head and back of male rough, of female comparatively smooth; the former leaden black above; almost or quite destitute of yellow; the latter uniformly mottled with black and yellow; beneath pale yellow, darker on sides, with fine irregular streaks and spots of black. Floridan district.

FAUNAL REGIONS OF UNITED STATES.

Austroriparian Region.—Bordered on the south and east by the Gulf of Mexico and the Atlantic; on the north and west by a line extending south through the eastern part of North and South Carolina, west through upper Georgia and Alabama, north through the western part of Tennesssee and Kentucky to Southern Illinois, west and south to Indian Territory, and across the western corner of Texas to New Mexico and the Rio Grande. It includes three districts: the *Floridan*—the southern portion of Florida; the *Louisianian*—from the Floridan to Texas; the *Texan*—Texas.

Eastern Region—Bordered on the south by the Austroriparian; on the east by the Atlantic; on the west by a line running north from the northeast corner of Indian Territory to the southeast corner of Dakota, thence northwest.

Pacific Region—Bordered on the east by the Sierra Nevada mountains; on the west by the Pacific; on the south by Lower California.

Lower Californian Region—Occupies the peninsula of that name.

Central Region—Bordered on the east and north by the Eastern; on the west by the Pacific; on the south by the Austroriparian and Sonoran regions.

Sonoran Region—Includes parts of Nevada, New Mexico, Arizona, and Sonora in Mexico.

GLOSSARY.

Alveolar surface—That portion of the jaws where the teeth are usually found.

Amphicœlian—Said of those vertebræ that are concave at each end.

Anal—Pertaining to the anus.

Anal plate—The plate or scale which covers the anus in front.

Anchylosed—Firmly united, as when bones are grown together.

Annulated—Ringed or banded transversely.

Anteorbital plate—That situated along the anterior margin of the eye, the largest dimension of which is vertical.

Areolate—Divided into small spaces which are bounded by parts differing in color or structure.

Articular bone—The portion of the lower jaw which articulates with the quadrate.

Azygos—A plate directly behind the rostral.

Branchiæ—Gills; the respiratory organs of fishes, etc.

Bridge—The bony or horny plates which unite the carapace and plastron of turtles.

Canthus—Corner or angle.

Canthus rostralis—Corner or angle of snout.

Carapace—The dorsal shield of turtles; usually composed of bony plates covered by horny scales.

Carinate—Keeled or ridged longitudinally.

Carpus—The wrist bones connecting the forearm with the long bones of the hand.

Clavicle—The collar-bone or anterior inferior portion of the pectoral arch. It does not form part of socket for arm.

Cloacal aperture—Entrance into the cloaca, or chamber into which the rectum, and the genital and urinary organs open.

Coccyx—The vertebræ of the tail, or those behind the sacrum.

Condyle—Articulating surface of a bone.

Connate—United into one body.

Coracoid—A bone or cartilage on the ventral side of an animal, which helps to form the socket for the articulation of the arm.

Coriaceous—Leathery.

Costal—Pertaining to or in relation with the ribs.

Costal grooves or plicæ—Grooves or folds between the ribs.

Cruciform—Cross-like.

Dentaries—Distal ossification of the mandible or lower jaw.

Depressed—Flattened.

Diaphragm—The muscular septum separating the thoracic and abdominal cavities.

Diapophyses—Transverse processes of the vertebræ.

Digits—Fingers and toes.

Distal—Remote from point of attachment.

Dorsal—Pertaining to the back or upper surface.

Edentulous—Without teeth.

Emarginate—Slightly notched at tip.

Epicoracoid—Equivalent to precoracoid of Huxley. It is a portion of the coracoid bone or cartilage lying in front of and more or less separated from the rest by a fontanelle.

Femoral pores—Pores along the under surface of the thigh.

Fontanelle—A space between bones occupied by a membrane.

Fossa—A depression or excavation more or less cup-shaped.

Fronto-parietal—A bone formed by, and occupying the place of, the frontal and parietal.

G. Gastrosteges—Transverse band-like plates on the abdomen.

Gular fold—A transverse fold across the throat.

Hypopophyses—A process from the median line of the under surface of the bodies of the vertebræ.

Iliac bones—That part of the pelvic bones which articulates with the vertebræ.

Imbricate—Overlapping, like shingles.

Internasals—Plates on top of snout, between nasals.

Isodont—Equal toothed.

Keel—Ridge.

Labials—Plates that border the mouth, except the rostral.

Loral—A plate between nostril and eye, whose longest dimension is longitudinal.

Mandible—The lower jaw.

Marginal plates—Those around the margin of the carapace.

Maxillary bones—Those at side of upper jaw, and separated in front by premaxillaries.

Metacarpals—Long bones in hand separating the carpals from the phalanges.

Metatarsals—Bones in foot separating tarsals from phalanges.

Nares—Openings of nose, external and internal.

Nasal—Pertaining to the nose.

Nasal plates—Those about the external nares.

Neural spine—The median dorsal spine of the vertebræ.

Nuchal—Pertaining to nape of neck.

Occipital plates—Those behind the vertical.

Ocellated—With eye-like spots, usually round with a lighter border.

Opisthocœlian—Said of the vertebræ when concave on the posterior end only.

Palatine teeth—Those on the palate bone; generally on anterior part of mouth.

Palmate—Webbed.

Papillose—Covered with papillæ or small fleshy projections.

Parotoid—A projecting gland behind jaw on side of neck.

Phalanges—The bones which form the fingers and toes.

Pectoral arch—The bones that support the fore limbs, as the clavicle, coracoid and scapula.

Pedicellate—With a stem, stalk, or foot.

Penultimate—Next to the last.

Plantar tubercles—Tubercles on the soles of the feet.

Plastron—The abdominal shield of turtles.

Pleurapophyses—The true ribs or their homologues.

Plicæ of tongue—Folds or grooves on the surface.

Plicate—Transversely folded or wrinkled.

Pollex—Thumb.

Postfrontal plate—One in front of vertical.

Postorbital plates—Those behind the eye.
Preanal pores—The pores in front of the anus.
Prefrontal plate—In front of postfrontal.
Premaxillary bones—Those which form anterior border of upper jaw, meeting in median line.
Procœlian—Vertebræ concave in front only.
Proximal—Nearest.
Pubis—The anterior segment of the lower portion of the pelvic bones.
Quadrate bone—The proximal bone in the series forming the lower jaw; the one by which the rest are joined to the cranium.
Reniform—Kidney-shaped.
Rostral plate—The one that forms the tip of the snout.
Rugosities—Roughnesses or wrinkles.
Semipalmate—Toes half webbed.
Serrated—With saw-tooth projections.
Sessile—Attached without any stalk or foot.
Squamosal—Like a scale.
Sternal plates—Those on the abdomen.
Sternal ribs—The ribs which are attached to the sternum.
Subapical—Near the apex.
Subcaudal—Beneath the tail.
Subcircular—Nearly round.
Subcylindrical—Almost cylindrical.
Subgular—On the throat or under surface of the neck.
Suborbital plates—Those between eye and labials.
Superciliary—Over the eye.
Superciliary plate—On top of head, over eye.
Supranasal plate—One above the nasal.
Symphyses—Junctures of bones, especially along median line.
Tarsal bones—Those in the ankle between the long bones of foot and leg.
Temporal plates—Between occipitals and labials.
Tympanum—The drum-head of the ear.
Ultimate—Last or farthest.
Vertebra—One of the bones of the back.

Vertebral—Along or in relation to the vertebræ.
Vertical plate—In center of top of head, between eyes.
Vesicle—A sack or bladder-like cavity.
Vomerine teeth—Those on vomer.
Vomeropalatine—Those on the united vomer and palate.
Xiphisternum—The posterior segment of the sternum.

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INDEX.

ERRATA.

P. 6. After description following Family PROTEIDÆ read:

Genus NECTURUS, Raf.

3. *N. lateralis*, (Say) Bd. Mud Puppy. Above brownish, with darker sub-circular spots; generally a dark stripe from snout back to eyes. A more or less distinct lateral band in young. Below dusky. Large, bushy, bright red gills, forming three tufts on each side of head. Head depressed; snout truncated; gular fold well developed; tail much compressed. $1\frac{1}{2}$ feet. Eastern region, except New England and Eastern Middle States, and from a few points in Austroriparian.

4. *N. punctatus*, (Gibbes) Cope. Above nearly uniform dark olive, with numerous small orange or yellowish dots irregularly distributed over the whole surface, and large, dark, ill-defined spots at distant intervals. No lateral band. Beneath pale flesh color. Smaller and more slender than the preceding species. Eastern S. Carolina.

P. 18. Before FIRMISTERNIA and ARCIFERA, for ORDER read SUB-ORDER.

P. 22. Before RANIFORMIA, for ORDER read SUB-ORDER.

STUDIES

OF THE

FOOD OF BIRDS, INSECTS AND FISHES,

MADE AT THE

ILLINOIS STATE LABORATORY OF NATURAL HISTORY,

AT

NORMAL, ILLINOIS.

EDWARD HINE, PRINTER, ADAMS STREET, CORNER HARRISON, PEORIA.

MAY, 1883.

THE REGULATIVE ACTION OF BIRDS UPON INSECT OSCILLATIONS.

By S. A. FORBES.

Attention has already been repeatedly called in these studies to the fact (fundamental to this investigation) that the principal injuries due to insects are done by a few species, existing, for a time, in numbers far above the average, and soon to retire again to a much lower limit. As the number of a species which reach maturity is determined by the checks on its multiplication, it follows that these oscillating species are held in check by variable forces, and to the variations in these checks we must look for an explanation of their oscillations. On the other hand, we must expect to find that those insects whose numbers remain relatively constant from year to year are under the control of restraining influences of a much more uniform character than the preceding class.

Concerning the effects of birds upon insect life, and through this upon the interests of agriculture, there are therefore three questions to answer:—

1. Do birds originate any oscillations among the species of insects upon which they feed? That is, are their food habits ever so inconstant from year to year that species which are at one time principal elements of their food, are at other times neglected and allowed to multiply without restraint?

2. Do birds prevent or restrain any oscillations of insects now noxious, or capable of becoming so if permitted to increase more freely? That is, do they bring to bear upon any such species a constant pressure so great that those insects would increase unduly if this pressure were removed by the destruction of the birds?

3. Do they do anything to reduce existing oscillations of injurious insects? Do they sometimes vary their food habits so far as to neglect their more usual food and take extraordinary numbers

of those species which, for any reason, became superabundant for a time ?

For the purpose of answering these questions, two separate lines of investigation are necessary. For the first two we require a knowledge of the food habits of the various species of birds under ordinary circumstances, when the conditions of life are of average character, and especially when no species of insects are unusually and excessively abundant. On the other hand, for an answer to the third question we must look to the food habits of the birds under extraordinary circumstances, where the opposite condition of affairs prevails. We must learn to what extent birds depart from their usual practices when confronted by an uprising of some insect species. If they concentrate for its suppression, they must assist more or less effectively to reduce to order the disturbed balance of life; but if they remain indifferent to this condition of things, their influence is *nil.*

The present paper is a contribution to a discussion of the last of the above questions. As a striking and conclusive example of an extraordinary condition of insect life, and of the food of birds in the presence of a disturbed balance of nature, I selected an orchard which had been for some years badly infested by canker-worms, shot a considerable number of birds therein for two successive years, representing nearly all the kinds seen in the orchard, made full notes of the relative abundance of the species, examined carefully the contents of all the stomachs obtained, with reference not only to the presence of canker-worms but of all other insects as well, and tabulated the results as the basis of this paper. Besides preparing as full an account of the food of these birds as practicable, I have brought the summaries on these tables into comparison with those derived from birds of the same species shot in ordinary situations during the same month. These comparisons have been confined to a few of the kinds obtained in the orchard, for the reason that most were not found there in sufficient number to give a fair idea of the average food of the species. The collections were made in an orchard of forty-five acres of bearing apple-trees (belonging to Mr. J. W. Robison) in Tazewell County, Ill., which had been infested by canker-worms for about six years. As a result of their depredations, a considerable part of the orchard had the appearance, from a little distance,

of having been ruined by fire. Closer examination of the trees most affected showed that the branches, stripped of every vestige of green, were festooned with the webbing left by the worms. To the webs the withered remnants of the leaves adhered as they fell, the very petioles having been gnawed off at the twigs. Not one per cent. of the trees were uninjured, and these were invariably on the outer part of the orchard. Those which had been attacked several years in succession were killed; and there was a large area in the midst of the orchard from which such trees had been removed. One did not need to enter the enclosure to learn that the birds were present in extraordinary numbers and variety. From every part of it arose a chorus of song more varied than I had ever heard in any similar area at that season of the year. Most of the common summer residents were found there; and upon a second visit in 1882 many of the migrant species likewise occurred. The first collection was made on the 24th of May, 1881, and the second on the 20th of the same month im the following year. The season was less advanced at the time of the second collection than at the first, so that the actual difference between the two was probably not less than two weeks. At the first visit fifty-four birds were taken, representing twenty-four species, and seven other species were noted in the orchard of which no specimens were obtained. On the second visit ninety-two birds were shot, representing thirty-one species, and four other species were seen. In 1881 the worms were nearly all fully grown, and many of them had already entered the ground for their transformation, so that the larvæ were less abundant than they had been earlier. In 1882 most of them were about half-grown, only a few having reached adult size. They were distinguishable with difficulty upon the leaves of the trees; but when a large branch was shaken or jarred, from a dozen to twenty would expose themselves by spinning down and hanging at the end of a thread. The owner of the orchard informed me that they were about twice as abundant the preceding season.

TURDIDÆ. Thrushes.

TURDUS MIGRATORIUS, L. ROBIN.

This species was abundant and nesting in the orchard. Nine specimens were obtained in all, three in 1881 and six in the fol-

lowing year. The food was wholly animal, neither fruit nor any other kind of vegetation having been taken by any of the birds. Only three of the above number had eaten canker-worms, which composed, as nearly as could be estimated, about one-fifth of the food of the entire group. Insects made ninety-three per cent., the remainder consisting of a common species of myriapod (five per cent.), earth-worms, and gasteropod mollusks. Ants were eaten by these birds only in trivial numbers. Diptera, Orthoptera and spiders were conspicuous by their entire absence. Cut-worms were extraordinarily prominent in the food, making twenty-eight per cent. of the whole. Half of them consisted of a single large, injurious species (*Nephelodes violans*). Among the Coleoptera, which amounted to thirty-six per cent. of the whole, the Scarabæidæ and Elateridæ were the principal elements, the former represented by eighteen per cent., and the latter by eleven. Among the Scarabæidæ was a species known as a vine leaf-chafer (*Anomala binotata*), which made fourteen per cent. of the food. This insect was scarcely less abundant than the canker-worm, and appeared in extraordinary numbers in the food of nearly all the species of birds examined, although it had not attracted the attention of the owner of the grounds. I searched a small vineyard adjacent, but saw no signs of unusual injury to the leaves. Carabidæ, although common in the orchard, had scarcely been touched by the robins, only a single specimen of the family occurring. Hemiptera were found but in trivial numbers, representing about equally the families Coreidæ and Cydnidæ. Hymenoptera were still less abundant, composing only one per cent. of the food.

Mimus carolinensis, L. Catbird.

This species was very common, and thoroughly at home among the trees, where it was doubtless nesting. Fourteen specimens were taken, three at the first visit and eleven at the second. With the exception of two per cent. of myriapods, their food consisted entirely of insects. Canker-worms had been eaten by eight of the birds, but not in any great number, as they composed but fifteen per cent. of the food of the species. A few cut-worms had been taken, and a larger number of other caterpillars, bringing the total for Lepidoptera up to about one-fourth of the food.

The catbird had shown its usual preference for ants, eating fourteen per cent. of these insects. These birds had taken an unusual number of Coleoptera, which made more than half the food, chiefly Scarabæidæ. About two-thirds of them belonged to the single species (*Anomala binotata*) mentioned above under the food of the robin. Three of these birds had likewise eaten large June bugs. Elateridæ and their larvæ occurred only in trivial quantities, while Carabidæ amounted to four per cent., chiefly Anisodactylus. As in the robin, Diptera, Orthoptera, and Arachnida, were not represented in the food.

Harporhynchus rufus, L. Brown Thrush.

This bird was not common in the orchard, and only four specimens were taken. The food of these was entirely animal, an unexpected circumstance, as the brown thrush usually feeds largely upon grain. Six per cent. of the food consisted of thousand-legs, and insects made the entire remainder. Lepidoptera were about one-fifth of the food, and half of these were canker-worms. Like the preceding species, this bird had eaten an enormous number of beetles, which amounted to two-thirds of its food. Twelve per cent. of the whole was Carabidæ, chiefly a species of Chlænius. Scarabæidæ stand at forty-four per cent., largely Diplotaxis, Melolontha, and Anomala. Six per cent. were Elateridæ, and three per cent. Rhynchophora. No specimens of the remaining orders had been eaten by these birds.

Summary of the Family.

Treating, now, of the twenty-seven thrushes mentioned as one group, we find that none of them had eaten any vegetation whatever; that ninety-six per cent. of their food consisted of insects (myriapods and earth-worms making up the remaining four per cent.); that sixteen per cent. was canker-worms; and only four per cent. predaceous beetles. The Anomala previously mentioned made just a fourth of their entire food, other Scarabæidæ bringing up the average of that family to thirty-eight per cent. Click beetles (Elateridæ) with their larvæ were five per cent. of the whole, and snout beetles (Rhynchophora) two per cent.

SAXICOLIDÆ. Bluebirds.

SIALIA SIALIS, L. BLUEBIRD.

This species was not at all abundant in the orchard in either year. Only one was taken in 1881, and four in 1882. All but two per cent. of the food of these five specimens consisted of insects, spiders making the remainder. Canker-worms were twelve per cent. of the food, and other Lepidoptera five per cent. additional. Two-thirds of the food consisted of Coleoptera. Carabidæ made more than one-third (twenty-three per cent.), belonging chiefly to a species (*Anisodactylus baltimorensis*) which depends largely upon vegetable food. Four of the birds had eaten *Anomala binotata*, which made thirty-six per cent. of the food of the whole. Five per cent. was Chrysomelidæ, and fifteen per cent. Hemiptera, all belonging to the family Cydnidæ.

PARIDÆ. Chickadees.

PARUS ATRICAPILLUS, L. BLACK-CAPPED CHICKADEE.

This little bird, unfortunately, was not at all common in the orchard; and only two specimens were taken, one in each year. Sixty-one per cent. of their food consisted of canker-worms, eaten by both the birds, and Coleoptera made the entire remainder. These were nearly all Cerambycidæ (*Psenocerus supernotatus*) and Rhynchophora of undetermined species, twenty-five per cent. of the former, and ten of the latter.

TROGLODYTIDÆ. Wrens.

TROGLODYTES DOMESTICUS, Bartr. HOUSE WREN.

Several specimens of this little species were observed, some of them evidently nesting. The food was chiefly insects,—all, in fact, but six per cent. of spiders and one of thousand-legs. Nearly half the food of these birds consisted of canker-worms, and other Lepidoptera and their larvæ brought the average of the order up to fifty-nine per cent. A few gnats and other Diptera (four per cent.) and five per cent. of ants were also noted. Coleoptera and Hemiptera were taken in nearly equal quantities, thirteen per cent. of the former and ten of the latter. Two of the

birds had eaten *Psenocerus supernotatus*, amounting to four per cent. of the food, and the other Coleoptera were scattered through the families Carabidæ, Nitidulidæ, Scarabæidæ, Elateridæ and Calandridæ. The Hemiptera were represented by trivial numbers of four families, including a few chinch bugs.

MNIOTILTIDÆ. Warblers.

HELMINTHOPHAGA PEREGRINA, Wils. TENNESSEE WARBLER.

A single specimen of this little warbler was taken in 1882. Four-fifths of its food consisted of canker-worms, and all the remainder of a single species of beetle (*Telephorus bilineatus*).

DENDRŒCA ÆSTIVA, Gmel. SUMMER YELLOW BIRD.

This bird, common every where at this season, was also abundant in the orchard. Five specimens were shot in all. The food was insects, excepting six per cent. of spiders. Two-thirds of the total amount eaten by all of the birds consisted of canker-worms. Coleoptera were twenty-three per cent. of the whole amount, six per cent. being Aphodius, and twelve per cent. *Psenocerus supernotatus*, already frequently mentioned. Carabidæ and Calandridæ were represented by insignificant ratios, and Lampyridæ by a single Telephorus eaten by one of the birds. One per cent. of Hemiptera, and two of Hymenoptera complete the record.

DENDRŒCA PENNSYLVANICA, L. CHESTNUT-SIDED WARBLER.

Two specimens of this abundant migrant were shot in the orchard in 1882. Like the preceding warbler, two-thirds of their food consisted of canker-worms, and an additional ten per cent. of other caterpillars. A few ants were eaten by both of the birds. Eleven per cent. of Coleoptera, likewise eaten by the two, was about equally divided between some undetermined Scarabæidæ and *Psenocerus supernotatus*. One of the birds had eaten plant-lice, which amounted to five per cent. of the food; and both had taken ants to the amount of six per cent.

DENDRŒCA STRIATA, Forst. BLACK-POLL WARBLER.

Four of these birds were shot in 1882. Some undetermined seeds found in the crop of one of them reduced the insect ratio

to ninety-five. Again two-thirds of the food consisted of canker-worms. The same little borer (*Psenocerus*) eaten by so many of the smaller birds in this orchard, made fifteen per cent. of the food; and an Aphodius and an undetermined carabid bring up the ratio of the Coleoptera to nineteen per cent. Four per cent. of ants, a few gnats (five per cent.), and traces of Hemiptera and mites were the only other elements detected.

Dendrœca virens, Gm. Black-throated Green Warbler.

A single specimen of this migrant was shot in 1882. Seventy per cent. of its food consisted of canker-worms, fifteen per cent. of Psenocerus, and five of undetermined Hemiptera. The remaining ten per cent. was made up of trivial numbers of Hymenoptera, gnats, coleopterous larvæ and mites.

Geothlypis trichas, L. Maryland Yellow-throat.

This resident warbler occurred but sparingly in the orchard. One specimen was seen in 1881, and two were obtained in 1882. Lepidoptera made four-fifths of their food, about èqually canker-worms and undetermined caterpillars. A few Staphylinidæ and some specimens of Psenocerus composed the eight per cent. of Coleoptera. A small hemipter (*Piesma cinerea*) amounted to five per cent., and four per cent. was gnats.

Summary of the Family.

Of the warbler family as a whole, as represented by these fifteen specimens, I need only remark that fourteen of the birds had eaten canker-worms, which composed nearly or quite two-thirds of the food of the group; that ten per cent. consisted of *Psenocerus supernotatus;* and that the remaining averages, with the exception of six per cent. of undetermined caterpillars, were so much subdivided as to have little or no significance.

VIREONIDÆ. Vireos.

Vireo gilvus, V. Warbling Vireo.

Three specimens of this little bird were shot, of purely insectivrous habit. They had eaten canker-worms to the amount of forty-four per cent.; and other oaterpillars made thirty-five per

cent. additional. A few Coleoptera (fifteen per cent.) of which one-third were carabid larvæ, and three per cent. of Cydnidæ (*Podisus*), were the only other important elements. *Anomala binotata* (eight per cent.), Telephorus, and an undetermined long-horn, were the other Coleoptera.

AMPELIDÆ. Wax-wings.

AMPELIS CEDRORUM, V. CEDAR WAX-WING.

A flock of about thirty of these birds was repeatedly started in the orchard during the first visit, but none were seen in 1882. Seven of the flock were shot, and the contents of their stomachs carefully studied. With the exception of a few Aphodii eaten by three of the birds in numbers too insignificant to figure in the ratios, the entire food of all these birds consisted of canker-worms, which therefore stand at an average of one hundred per cent. The number in each stomach, determined by actual count, ranged from seventy to one hundred and one, and was usually nearly a hundred. Assuming that these constituted a whole day's food, the thirty birds were destroying three thousand worms a day, or ninety thousand for the month during which the caterpillar is exposed.

HIRUNDINIDÆ. Swallows.

PETROCHELIDON LUNIFRONS, Say. CLIFF SWALLOW.

This species was nesting in great numbers under the eaves of a barn at the edge of the orchard, and many of the birds were continually circling through the air. A single specimen was shot, and found to contain nothing but the very abundant scavenger beetle (*Aphodius inquinatus*), with about two per cent. of undetermined Hemiptera.

FRINGILLIDÆ. Finches.

ASTRAGALINUS TRISTIS, L. AMERICAN GOLDFINCH.

A flock of these birds passed through the orchard, but only a single one was shot. No canker-worms had been eaten by it; but about seventy per cent. of its food consisted of undetermined seeds, and the remainder of a harpalid beetle.

COTURNICULUS PASSERINUS, Wils. YELLOW-WINGED SPARROW.

A single specimen of this bird, shot in 1881, contained spiders thirty per cent., seeds of pigeon grass (*Setaria*) fifteen per cent., an unrecognized beetle five per cent., and some undetermined caterpillars, certainly not canker-worms.

SPIZELLA DOMESTICA, Bart. CHIPPING SPARROW.

This species was not common in the orchard in 1881, and only a single specimen was obtained; but in the following year it was found much more abundant, and seven additional were taken. About one-third of the food consisted of caterpillars, half of which were recognizable as canker-worms. A large number of gnats (twenty-eight per cent.), nearly as many Coleoptera, (principally Scarabæidæ, including nine per cent. of Anomala), and six per cent. of Hemiptera, are all the other noteworthy items.

SPIZELLA AGRESTIS, Bart. FIELD SPARROW.

This species was less abundant than the preceding, and was represented by only three specimens. With the exception of five per cent. of gnats, and one of Hemiptera, the food of this bird was equally divided between Lepidoptera and Coleoptera. Nearly half the former consisted of canker-worms, while the Coleoptera were represented by Histeridæ, Scarabæidæ (chiefly the scavengers), Monocrepidius and Rhynchophora.

SPIZA AMERICANA, Gmel. BLACK-THROATED BUNTING.

This bird was the most abundant species in 1881, though but few were seen during the following May. Eleven were shot at the first visit and three at the second. With the exception of a little wheat eaten by two of the birds, and a trace of undetermined seeds, the food consisted almost entirely of insects and mollusks, eighty-eight per cent. of the former and six of the latter (Helix). Ten of these birds had eaten canker-worms, which made forty-three per cent. of the food of the entire group; Lepidoptera as a whole composing two-thirds of the food. Among the twenty-two per cent. of Coleoptera, we note Harpalus and Histeridæ, each four per cent., Aphodius and Anomala likewise each four per cent., and Sphenophorus and other Rhynchophora, two per cent.

ZAMELODIA LUDOVICIANA, L. ROSE-BREASTED GROSBEAK.

Only two were seen, and both were killed. A very few canker-worms were found (five per cent.) with fifty-eight per cent. of other caterpillars. About half the fifteen per cent. of Coleoptera were Rhynchophora, the remainder being *Anomala binotata*, one of the Lampyridæ, and undetermined specimens. One-fifth of the food consisted of seeds not recognized.

PASSERINA CYANEA, L. INDIGO BIRD.

This bird, noted as common in 1881, was by far the most abundant species in the orchard at the second visit. Eighteen specimens were shot, two in the first and the remainder in the second year. Although this bird is one of the typical finches, only three per cent. of its food consisted of seeds, chiefly Setaria and Compositæ. Canker-worms made fifty-nine per cent., eaten by all the birds but one, and other caterpillars an additional eight per cent. With the exception of a trace of Hymenoptera, the remainder of the food consisted entirely of beetles, about one-third of which were *Anomala binotata*.

Summary of the Family.

Only seven per cent. of the food of the forty-seven members of this family (commonly called seed-eaters) consisted in fact of seeds; and insects made up all but two per cent. of the remainder. The most interesting items on the general list are canker-worms forty per cent., predaceous beetles (Carabidæ) two per cent., and *Anomala binotata* six per cent.

ICTERIDÆ. Blackbirds.

MOLOTHRUS ATER, Bodd. COWBIRD.

A single wandering specimen of this bird contained only Scarabæidæ, including Aphodius, and a few other Coleoptera, with about sixty per cent. of corn and some seeds of Polygonum and other plants.

AGELÆUS PHŒNICEUS, L. RED-WINGED BLACKBIRD.

Two specimens of this bird, which were also accidentally in the orchard, had fed about equally upon insects and upon wheat and

other seeds. The Lepidoptera (twenty-seven per cent.) were nearly all the larvæ of *Nephelodes violans.* Of the Coleoptera (eleven per cent.), part were Anomala and Elateridæ, and the remainder consisted of specimens of *Tanymecus confertus*, eaten by one of the birds. A grasshopper had also been taken by one, making ten per cent. of the food; and traces of Hemiptera were recognized.

Icterus galbula, L. Baltimore Oriole.

Not common. Three were shot. These had fed only on insects,—Lepidoptera forty per cent. and Coleoptera sixty per cent., the former all canker-worms, and the latter chiefly *Anomala binotata* (fifty per cent.). Six per cent. of Cerambycidæ and two of Rhynchophora should also be mentioned.

Icterus spurius. L. Orchard Oriole.

This bird was common in 1881, although but two were shot; but was not noticed the next year. More than three-fourths of the food of these consisted of canker-worms, and other caterpillars made an additional twenty per cent., leaving but three per cent. for ants.

Quiscalus purpureus æneus, Bartr. Bronzed Grackle.

Wandering specimens of the grackle were seen, and a few were apparently roosting in the trees at night. But three were shot, all of which had fed chiefly upon corn, which amounted to sixty-two per cent. of their food. Fragments of a crawfish were found in the stomach of one. Half the thirty per cent. of Coleoptera were Carabidæ, including a specimen of *Calosoma calidum*, and the remainder were nearly all Lucanidæ (Dorcus, eight per cent.) and undetermined Elateridæ.

Summary of the Family.

The five species of this family mentioned were represented by but eleven specimens, which, taken together, were found to have made two-thirds of their food of insects, the remaining third of corn and wheat with a few seeds of weeds. Canker-worms, eaten by the orioles, only amounted to one-fourth of the food of the whole,

and Coleoptera to a little more than another fourth. Of these, Carabidæ made four per cent., Cerambycidæ two, Rhynchophora one, and *Anomala binotata* fourteen.

TYRANNIDÆ. Flycatchers.

TYRANNUS CAROLINENSIS, L. KINGBIRD.

This species was not uncommon, but only three were shot. Two of these, to my surprise, were found to have eaten canker-worms, which made more than a fourth of the food of the whole. Five per cent. of the remainder consisted of undetermined Hemiptera, and all the balance was Coleoptera. Seven per cent. was Elateridæ, two Lampyridæ, and more than fifty-eight Scarabæidæ, all Anomala except thirteen per cent. of *Aphodius inquinatus*, eaten by one of the birds.

CONTOPUS VIRENS, L. WOOD PEWEE.

Three of these were shot, none of which had taken canker-worms. Their food consisted chiefly of flies and gnats, which amounted to fifty-five per cent. Thirteen per cent. of Aphodius and ten per cent. of Ips, with a few ants and other Hymenoptera, are also worthy of mention.

EMPIDONAX TRAILLI, Aud. TRAILL'S FLYCATCHER.

Two specimens, shot in 1882, had eaten only insects, one-fourth of which were canker-worms, and one-third Ichneumonidæ. Another fourth consisted of Coleoptera, nearly half of which were Anomala; and ten per cent. were ants and other Hymenoptera.

EMPIDONAX FLAVIVENTRIS, Bd. YELLOW-BELLIED FLYCATCHER.

A single specimen had eaten a number of Lepidoptera and their larvæ, but no canker-worms. Half the food was Coleoptera, nearly all Aphodius and *Anomala binotata*,—fifteen per cent. and twenty-five per cent. respectively. The little Psenocerus was likewise taken by this bird, and a specimen of Hymenarcys (Hemiptera).

Summary of the Family.

The nine flycatchers taken had eaten only insects, of which nearly half were Coleoptera, and the remainder were about equally distributed between the Hemiptera, Lepidoptera, and Diptera. Canker-worms make fifteen per cent. of the whole, and *Anomala binotata* seventeen per cent. The Scarabæidæ include all but ten per cent. of the Coleoptera.

CUCULIDÆ. Cuckoos.

Coccyzus erythrophthalmus, Wils. Black-billed Cuckoo.

Three-fourths of the food of a single specimen shot consisted of canker-worms, other caterpillars making an additional twenty per cent. *Anomala binotata* was the only remaining element.

PICIDÆ. Woodpeckers.

Melanerpes erythrocephalus, L. Red-headed Woodpecker.

This bird was abundant in the orchard, evidently nesting in the trees, although but four specimens were shot. Two of these had eaten corn, which amounted to twenty per cent. of the food. Fifteen per cent. was canker-worms, and twenty-four per cent. Carabidæ (eaten by two of the birds), including Calosoma, Scarites, and several Harpalids. Twenty-nine per cent. of Scarabæidæ embraced a Canthon and some specimens of *Anomala binotata.* Melanotus and other spring-beetles were also eaten by two of the birds.

Colaptes auratus, L. Flicker.

A single specimen, killed in 1881, had fed only on ants, the usual aliment of the bird.

COLUMBIDÆ. Doves and Pigeons.

Zenaidura carolinensis, L. Mourning Dove.

Several mourning doves were seen, and a single specimen was taken. Three-fourths of the food of this was corn, and the remainder the seeds of some leguminous plant.

PERDICIDÆ. Quails and Partridges.

ORTYX VIRGINIANA, L. QUAIL.

Two quails were shot, among half a dozen seen. All but four per cent. of their food consisted of corn and other seeds, chiefly those of Compositæ. A single chrysomelid, a rhynchophorous beetle, and a carabid, were the only insects found.

Besides the species of birds above mentioned, the following were noted rarely in the orchard, but no specimens were secured: and *Vireo olivaceus*, *Sturnella magna*, *Cyanurus cristatus*, and *Chætura pelasgica*. The blue jay was seen eating canker-worms in the trees. The total number of species observed in the orchard wa therefore forty, and the number of specimens obtained and studied was one hundred and forty-one, representing thirty-six of the species. Twenty-six of these species had been eating canker-worms, which were found in the stomachs of eighty-five specimens. That is to say, seventy-two per cent. of the species, and sixty per cent. of the specimens, had eaten the worms. Taking the entire assemblage of one hundred and forty-one birds as one group, we find that thirty-five per cent. of their food consisted of canker-worms; and if we exclude the species evidently merely accidental in the orchard, the average of canker-worms in the food of those properly belonging there rises to about forty per cent.

For a correct estimate of the probable effect of the birds in limiting the increase of the canker-worm, it is necessary to take into account some of the features of its natural history. The larval life of the insect lasts about one month, after which it enters the ground and pupates, where it remains until the following spring. The imagos, the females of which are wingless, emerge about the middle of April. They lay their eggs upon the bark of the trees, usually at night, remaining concealed upon the ground by day under fallen leaves and other rubbish. The eggs remain upon the trees about a month before the worms emerge, when the latter crawl up the trunk and commence their attacks upon the leaves. The pest is consequently exposed to destruction from the time it emerges until it disappears again, the adults falling an easy prey to birds which search the ground for

food, and the eggs to the small species which pry about the trunks of trees. The entire period during which the insect is doubtless fed upon by birds will usually amount to somewhat more than two months.

Besides the abundance of the canker-worms noted in the food of these birds, it is evident that two or three other species of insects occurred in this situation in extraordinary numbers, especially the vine leaf-chafer (*Anomala binotata*) and a small borer (*Psenocerus supernotatus*). The purple cut-worm (*Nephelodes violans*) was also somewhat commoner than usual. The Anomala was eaten by thirty-nine of the specimens, representing fifteen species, and amounted to eleven per cent. of the food of all the birds taken in the orchard. Many of these were too small to feed upon so large an insect, and a better illustration of the abundance of this beetle may be gathered from the food of the thrushes and blue-bird. Of thirty-two specimens of these families, nineteen had eaten the vine leaf-chafer, which amounted to twenty-seven per cent. of the food of all. Only fourteen of the same birds had eaten the canker-worm, which amounted to less than twenty per cent. of the food. It seems likely, therefore, that some of these birds were attracted to the orchard, not by the canker-worms, but by the superabundance of Anomala. The unusual frequency of *Psenocerus supernotatus*, a small long-horned beetle found upon the trees, is shown by the fact that of the twenty-five small arboreal birds (Paridæ, Troglodytidæ, and Mniotiltidæ), thirteen had eaten this beetle, which composed nearly one-tenth of their food.

We have next to make the comparison of the food taken in the orchard by the species most abundant there, with the food of the same species, taken elsewhere under ordinary circumstances. For the purpose of this comparison I have selected the robin, the catbird, the black-throated bunting (*Spiza americana*), and the indigo bird (*Passerina cyanea*). In the table of the ordinary food of the robin for May, published in Bulletin 3 of this series, as represented by fourteen specimens, caterpillars amounted to but twenty-three per cent., whereas in the orchard they rise to fifty-four per cent. This difference between the averages is almost exactly accounted for by the ratios of canker-worms and *Nephelodes violans* not appearing on the former table; these together amounting to thirty-five

per cent. Notwithstanding the number of Anomala eaten in the orchard, the ratios of the Scarabæidæ are substantially the same, as the ordinary food of the robin in May consists largely of June beetles. The surplus of Lepidoptera seems to be balanced by a deficiency in all the other orders, no one of which rises to the average of its ordinary food in May. The loss is greatest, however, in the Diptera, which drop from eleven per cent. to nothing.

Comparing the record of the fourteen catbirds shot in the orchard with that of twenty-two obtained in miscellaneous situations, we note, first, that the caterpillars on the first table are more than twice those of the second,—twenty-six in the one, and twelve in the other; and that this difference is evidently due to the fifteen per cent. of canker-worms taken by the birds of the first group. This shows that the catbird, like the robin, had simply added the canker-worms eaten to its usual ratio of caterpillars. A more striking difference is shown in the totals of Coleoptera, which stand at fifty-six per cent. in the orchard birds, and twenty-three in the others. This, again, is evidently due to the abundance of *Anomala binotata;* for when the ratio of this insect is subtracted from the total of Coleoptera, the remainder is twenty per cent. as against twenty-three of the ordinary food. These excessive ratios of Lepidoptera and Coleoptera are compensated by deficiencies in the Diptera, Arachnida, Myriapoda and Orthoptera, especially in the three first named groups. The decided preference of this bird for ants is shown by the fact that the usual ratio of these insects is scarcely diminished, fourteen per cent. having been taken in the orchard and eighteen elsewhere.

Fourteen of the black-throated bunting (*Spiza americana*), killed in the orchard, are to be contrasted with twelve shot in May from various situations. A striking difference is seen at once in the insect ratios, which amount respectively to eighty-eight and forty-seven per cent. This surplus of insects eaten by the orchard birds is readily traced to the orders Lepidoptera and Coleoptera. Of the former these birds had eaten more than three times their ordinary average, and of the latter nearly four times the usual amount. The excess of Lepidoptera is clearly due, as usual, to the presence of the canker-worms, since the balance left

after subtracting the canker-worm ratio from the average of that order taken by the first group, differs by only three per cent. from the average taken by the second group. The discrepancy in the ratios of Coleoptera is not so easily explained, but is distributed among several genera of Scarabæidæ and the small scavenger beetles. The excess of these two orders is compensated principally by diminished ratios of vegetation, which amount to only six per cent. in the birds shot in the orchard, and fifty-two per cent. among those taken through the country at large. Diptera and all the lower orders of insects as well as Arachnida and Myriapoda, are also omitted from the food of the orchard birds.

Insects composed ninety-seven per cent. of the food of eighteen indigo birds (*Passerina cyanea*) shot in the orchard, and but fifty-seven per cent. of the food of fifteen individuals taken elsewhere, the balance in both cases being seeds, chiefly Setaria, Polygonum and wheat. The excess of insects in the orchard specimens appears under Lepidoptera and Coleoptera, the former sixty-seven per cent., the latter twenty-nine, as compared with twenty-eight and nineteen per cent. respectively, in the other group. The Lepidoptera of the orchard birds are nearly all canker-worms, as are likewise ten per cent. of those taken by the specimens from various situations. The difference in the ratio of Coleoptera taken by the two groups was exactly compensated by the ten per cent. of *Anomala binotata* eaten in the orchard. The excess of caterpillars and beetles taken by the former group, is partly compensated also by the almost total disappearance of all other insects from the food.

What, now, may we conclude, from the above data, respecting the influence of birds upon such entomological insurrections as are illustrated by the uprising of the canker-worms in Mr. Robison's orchard?

Three facts stand out very clearly as results of these investigations: 1. Birds of the most varied character and habits, migrant and resident, of all sizes, from the tiny wren to the bluejay, birds of the forest, garden and meadow, those of arboreal and those of terrestrial habit, were certainly either attracted or detained here by the bountiful supply of insect food, and were feeding freely upon the species most abundant. That thirty-five

per cent. of the food of all the birds congregated in this orchard should have consisted of a single species of insect, is a fact so extraordinary that its meaning can not be mistaken. Whatever power the birds of this vicinity possessed as checks upon destructive irruptions of insect life, was being largely exerted here to restore the broken balance of organic nature. And while looking for their influence over one insect outbreak we stumbled upon at least two others, less marked, perhaps incipient, but evident enough to express themselves clearly in the changed food ratios of the birds.

2. The comparisons made show plainly that the reflex effect of this concentration on two or three unusually numerous insects was so widely distributed over the ordinary elements of their food that no especial chance was given for the rise of new fluctuations among the species commonly eaten. That is to say, the abnormal pressure put upon the canker-worm and vine chafer was compensated by a general diminution of the ratios of all the other elements, and not by a neglect of one or two alone. If the latter had been the case, the criticism might easily have been made that the birds, in helping to reduce one oscillation, were setting others on foot.

3. The fact that, with the exception of the indigo bird, the species whose records in the orchard were compared with those made elsewhere, had eaten in the former situation as many caterpillars other than canker-worms as usual, simply adding their canker-worm ratios to those of other caterpillars, goes to show that these insects are favorites with a majority of birds.

TABLES OF THE FOOD.

	Turdidæ.				Sialidæ.	Paridæ.	Troglodytidæ.	Mniotiltidæ.						
	Robin.	Catbird.	Brown Thrush.	Total.	Bluebird.	Black-capped Chickadee.	House Wren.	Tennessee Warbler.	Summer Yellow Bird.	Chestnut-sided Warbler.	Black-poll Warbler.	Black-throated Green Warbler.	Maryland Yellow-throat.	Total.
Number of Birds.......	9	14	4	27	5	2	5	1	5	2	4	1	2	15
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Animal Food............	9 1.00	14 1.00	4 1.00	27 1.00	5 1.00	2 1.00	5 1 00	1 1.00	5 1.00	2 1.00	4 .95	1 1 00	2 1.00	15 .99
I. MOLLUSCA.	3 .01	....	....	3 †	....	....	....	....	....	....	....	....	....	....
II. INSECTA	9 .93	14 .98	4 .94	27 .96	5 .98	2 1.00	5 .91	1 1.00	5 .94	2 1.00	4 .95	1 1.00	2 1.00	15 97
1. *Hymenoptera*.	4 .01	11 .14	2 .03	17 .08	....	....	2 .05	...	2 .02	2 07	3 .04	1 .02	...	8 .03
Formicidæ..........	4 .01	11 .14	2 .03	17 .08	....	...	2 .05	....	....	2 .06	3 .04	...	...	5 .02
2. *Lepidoptera*	9 .54	12 .26	4 .22	25 .34	3 17	2 .61	5 .39	1 .80	5 .67	2 .75	4 .66	1 .70	2 .82	15 .71
Noctuidæ (larvæ)...	6 .28	5 .04	1 .05	12 .12	..	...	....	...	....	....	...	....	.	....
Nephelodes violans (larvæ)........	3 .14	1 .01	....	4 .05	....	...	....	....	...	....	...	....	...	...
Anisopteryx vernata	3 .21	8 .15	2 .12	13 .16	1 .12	2 .61	3 .46	1 .80	5 .67	2 .65	4 .66	1 .70	1 .37	14 64
3. *Diptera*	...	....	....	....	....	....	3 .04	....	1 .01	2 .02	4 .05	1 .05	2 .04	10 .03
Gnats..............	...	....	....	....	....	..	2 .03	....	..	1 .02	4 .05	1 .05	2 .04	8 .03
4. *Coleoptera*	9 .36	14 .56	4 .67	27 .51	5 .66	2 .39	5 .13	1 .20	5 .23	2 .11	4 .19	1 .08	1 .08	14 .18
Carabidæ	4 .01	5 .04	3 .12	12 .04	3 .23	....	1 .01	....	1 .01	....	1 .01	....	....	2 .01
Staphylinidæ.......	1 .04	....	....	1 .01	....	....	....	....	....	....	....	....	1 .05	1 .01
Phalacridæ	....	....	....	....	....	....	1 †	....	....	....	....	....	....	....
Histeridæ...........	5 .01	2 †	1 .02	8 .01	....	....	...	....	....	....	....	....	....	....
Scarabæidæ.........	6 .18	12 .49	3 .44	21 .38	5 .36	....	1 .01	....	1 .06	1 .05	1 .02	....	....	3 .03
Anomala binotata	3 .14	10 .36	2 .14	15 .25	4 .36	....	....	....	...	....	....	....	....	....
Elateridæ......	6 .11	1 .01	3 .06	10 .05	....	....	1 .01	....	....	....	....	....	....	....
Lampyridæ.........	....	....	....	....	....	....	....	1 .20	1 .04	....	....	....	....	2 .03
Cerambycidæ.......	....	....	....	....	....	1 .25	2 .04	....	3 .12	2 .06	3 .15	1 .15	1 .03	10 .10
Psenocerus supernotatus..	....	..	....	...	....	....	....	....	3 .12	2 .06	3 .15	1 .15	1 .03	10 .10
Chrysomelidæ......	....	....	....	....	1 .05	...	....	....	....	.	....	....	...	....
Rhynchophora	3 .01	3 .01	1 .03	7 .02	....	1 .10	1 .01	....	1 †	....	....	....	....	1 †
5. *Hemiptera*..	3 .02	6 .02	. .	9 .02	3 .15	....	4 .10	....	2 .01	1 .05	1 .01	1 .05	2 .06	7 .02

TABLES OF THE FOOD—Continued.

	Robin.	Catbird.	Brown Thrush.	Total.	Bluebird.	Black-capped Chickadee.	House Wren.	Tennessee Warbler.	Summer Yellow Bird.	Chestnut-sided Warbler.	Black-poll Warbler.	Black-throated Green Warbler.	Maryland Yellow-throat.	Total.
Number of Birds..	9	14	4	27	5	2	5	1	5	2	4	1	2	15
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Homoptera........	....	....	..	....	....	....	1 .02	....	....	1 .05	....	....	....	....
Aphides...........	....	....	....	...	....	....	....	....	....	1 .05	...	....	....	....
Tettigonidæ		....	....	...	...	....	1 .02	....	....	....	..	....	....	....
Heteroptera........	3 .02	4 02	....	6 .02	3 .15	....	1 .06	...	....	....	...	...	1 .05	1 †
Aradidæ	....	....	....	....	....	....	1 .02	....	....	....	....	....	....	....
Lygæidæ...	....	....	....	....	....	....	1 .02	....	....	....	....	....	1 .05	1 †
Chinchbugs....		....	....	..	....	....	1 .02	....	....	....	....	...	....	....
Coreidæ....... ...	1 .01	...	....	1 .01	....	....	..	....	....	....	....	....	...	....
Cydnidæ..........	2 .01	3 .02	....	5 .01	3 .15	...	...	....	....	....	....	....	....	....
III. ARACHNIDA.... ...	...	....	...	...	2 .02	....	3 .06	....	3 .06	....	1 †	1 †	5 .02	....
IV. MYRIAPODA..	2 05	2 .02	1 .06	5 .03	..	....	1 01	..	....	....	....	....	....	....
VI. VERMES (Lumbricus)..........	1 .01	....	....	1 .01	....	....	...	....	....	....	....	....	..	....
Vegetable Food (seeds).	....	....	....	...	....		..	.	....	....	1 .05	...	1 .01	....

TABLES OF THE FOOD — Continued.

	Vireonidæ.	Ampelidæ.	Hirundinidæ	Fringillidæ.								Icteridæ.		
	Warbling Vireo.	Cedar Wax-wing.	Cliff Swallow.	American Goldfinch.	Yellow-winged Sparrow.	Chipping Sparrow	Field Sparrow.	Black-throated Bunting.	Rose-breasted Grosbeak.	Indigo Bird	Total.	Cowbird.	Red-winged Blackbird.	Baltimore Oriole.
Number of Birds.......	3	7	1	1	1	8	3	14	2	18	47	1	2	3
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Animal Food...........	3 1.00	7 1.00	1 1.00	1 .30	1 .65	8 .96	3 1.00	14 .94	2 .80	18 .97	47 .93	1 .30	2 .50	3 1.00
I. MOLLUSCA	....	....	....	....	....	....	....	1 .06	....	....	1 .01	....	....	....
II. INSECTA............	3 1.00	7 1.00	1 1.00	1 .30	1 .35	8 .95	3 1.00	14 .88	2 .80	18 .97	47 .91	1 .30	2 .50	3 1.00
1. *Hymenoptera*	....	1 †	1 .02	....	....	3 .03	....	3 .01	1 .02	2 .01	8 .01	....	....	....
Formicidæ.........	....	....	....	....	....	1 .01	....	1 †	....	....	2 †	....	....	....
Tenthredinidæ....	....	....	....	....	....	1 .02	....	....	....	....	1 .01	....	....	....
2. *Lepidoptera*........	3 .79	7 1.00	....	....	1 .30	7 .32	3 .47	13 .65	2 .63	17 .67	43 .57	....	2 .29	3 .40
Noctuidæ.........	....	....	....	....	....	....	....	2 .14	....	....	2 .04	....	1 .25	....
Nephelodes violans (larvæ)...	....	....	....	....	....	....	....	....	....	....	....	....	1 .25	....
Phalænidæ (larvæ)	3 .44	7 1.00	....	....	....	2 .16	1 .20	10 .46	1 .05	17 .60	31 .41	....	1 .01	3 .40
Anisopteryx vernata.........	3 .44	7 1.00	....	....	....	2 .16	1 .20	10 .43	1 .05	17 .59	31 .40	....	1 .01	3 .40
3. *Diptera*............	1 .03	....	....	....	....	7 .28	1 .05	....	....	....	8 .05	....	....	....
Gnats...............	....	....	....	....	....	7 .28	1 .05	....	....	....	8 .05	....	....	....
Muscidæ............	1 03	....	....	....	....	....	....	....	....	....	....	....	....	....
4. *Coleoptera*..........	2 .15	3 †	1 .98	1 .30	1 .05	7 .25	3 .47	11 .22	2 .15	18 .29	43 .26	1 .30	2 .11	2 .60
Carabidæ	2 .05	....	....	1 .30	....	....	....	3 .04	....	....	4 .02	....	....	....
Nitidulidæ..........	....	....	....	....	....	....	....	1 .01	....	....	1 †	....	....	....
Histeridæ	....	....	....	....	....	....	1 .03	3 .04	....	1 .01	5 .01	....	....	....
Trogositidæ	....	....	....	....	....	....	....	....	....	....	....	....	....	1 .01
Scarabæidæ.........	1 .08	3 †	1 .98	....	....	3 .14	3 .08	7 .11	1 .02	9 .15	23 .12	1 .25	1 .03	3 .50
Anomala binotata	1 .08	....	....	....	....	2 .09	....	2 .04	1 .02	4 .10	9 .06	....	1 .03	3 .50
Elateridæ	....	....	....	....	....	....	1 .01	....	....	2 .01	3 .01	....	1 .04	1 .01
Lampyridæ.........	....	....	....	....	....	....	....	....	1 †	....	1 †	....	....	....
Cerambycidæ.......	1 .02	....	....	....	....	....	....	....	....	....	....	....	....	3 .06
Psenocerus supernotatus......	....	....	....	....	....	....	....	....	....	....	....	....	....	1 .02
Chrysomelidæ	....	....	....	....	....	2 .01	....	....	....	....	2 †	1 .02	....	....

TABLES OF THE FOOD—Continued.

	Warbling Vireo.	Cedar Wax-wing.	Cliff Swallow.	American Goldfinch.	Yellow-winged Sparrow.	Chipping Sparrow	Field Sparrow.	Black-throated Bunting.	Rose-breasted Grosbeak.	Indigo Bird.	Total.	Cowbird.	Red-winged Blackbird.	Baltimore Oriole.
Number of Birds	3	7	1	1	1	8	3	14	2	18	47	1	2	3
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Rhynchophora	...	...	...	...	...	1 .01	3 .08	6 .02	2 .08	6 .03	18 .03	...	1 .04	1 .02
5. *Hemiptera*	1 .03	...	...	...	..	5 .06	1 .01	...	...	1 †	7 .01	...	1 †	...
Homoptera	...	...	...	...	...	...	...	...	...	1 †	1 †	...	1 †	...
Heteroptera	...	...	...	..	...	1 .03	...	...	...	...	1 †	...	...	...
Lygæidæ	...	...	...	...	...	1 .03	...	..	...	...	1 .01	...	...	...
Cydnidæ	1 .03	.	...		..	...	...	...	...	...	...	...	...	...
6. *Orthoptera* (Acrididæ)	...	...	...	..	...	.	...	...	...	...	...	...	1 .10	...
III. ARACHNIDA	...	..	...	.	1 .30	6 .01	2 †	...	...	...	9 .01	...	...	...
Vegetable Food (seeds)	...	...	..	1 .70	1 .35	4 .04	...	3 .06	2 .20	6 .03	17 .07	1 .70	2 .50	...
Compositæ	...	..	...	...	...	...	...	...	...	2 .01	2 .01	...	...	...
Polygonum	...	..	..	...	...	...	...	...	...	...	...	1 .05	1 05	...
Wheat	...	...	...	...			...	1 .05	...	...	1 .02	...	1 .45	...
Setaria	...	...	...	...	1 .15	2 .01	...	2 †	...	2 .01	7 .01	...	...	...
Corn	...	...	..	...	.	...	...	...	...	...	...	1 .60	...	...
Panicum	..			.	...	1 .01	...	.	...	.	1 †	...	...	...

TABLES OF THE FOOD — Continued.

	Icteridæ			Tyrannidæ.					Cuculidæ.	Picidæ.			Columbidæ.	Perdicidæ.
	Orchard Oriole.	Bronzed Grackle.	Total.	King Bird.	Wood Pewee.	Traill's Flycatcher	Yellow-bellied Flycatcher.	Total.	Black-billed Cuckoo.	Red-headed Woodpecker.	Flicker.	Total.	Mourning Dove.	Quail.
Number of Birds......	2	3	11	3	3	2	1	9	1	4	1	5	1	2
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Animal Food...........	2 1 00	3 .38	11 .68	3 1.00	3 1 00	2 1 00	1 1.00	9 1.00	1 1 00	4 .80	1 1.00	5 .84	....	2 .04
II. INSECTA	2 1.00	3 .30	11 66	3 1 00	3 1.00	2 1.00	1 1.00	9 1.00	1 1.00	4 .80	1 1.00	5 .84	....	2 .04
1. *Hymenoptera*.......	1 .03	....	1 .01	1 .05	2 .12	2 .48	1 .02	6 .16	....	1 .01	1 1.00	2 .21	....	....
Formicidæ	1 .03	....	1 .01	...	1 .04	1 .05	....	2 .02	....	1 .01	1 1.00	2 .21	....	....
Ichneumonidæ	....	....	....	....	....	1 .33	....	1 .07	....	....	....	....	....	....
2. *Lepidoptera*.........	2 .97	....	7 .34	2 .28	1 .05	1 .25	1 .30	5 .20	1 .95	1 .15	....	1 .12	....	....
Noctuidæ(larvæ)....	....	...	1 .05	....	....	....	....	....	....	....	....	....	...	....
Nephelodes violans (larvæ)...	..	....	1 05	....	....	....	....	....	....	....	....	....	...	....
Phalænidæ (larvæ).	2 .77	....	6 .25	2 .28	....	1 .25	....	3 .15	1 .75	1 .15	....	1 .12	....	....
Anisopteryx vernata	2 .77	....	6 .25	2 .28	....	1 .25	....	3 .15	1 .75	1 .15	....	1 .12	....	....
3. *Diptera*	....	..	....	....	3 .55	....	1 .08	4 .19	....	....	...	....	....	....
Tipulidæ............	...	....	....	....	....	....	1 .08	1 .01	....	....	....	...	....	....
Gnats..............	....	....	....	....	1 .23	....	....	1 .08	....	....	....	....	....	....
Muscidæ..	....	....	....	....	2 .32	....	....	2 .10	....	....	....	....	....	....
4. *Coleoptera*..........	....	3 .30	8 .29	3 .67	2 .28	2 .25	1 .50	8 .43	1 .05	4 .64	....	4 .51	....	2 .04
Carabidæ............	....	3 .16	3 .04	....	....	....	....	....	....	2 .24	....	2 .19	....	1 .01
Nitidulidæ..........	....	....	....	....	1 .10	....	....	1 .03	....	....	....	....	....	....
Trogositidæ.........	....	....	1 †	....	....	....	....	....	....	....	....	....	....	....
Lucanidæ...........	....	1 .08	1 .02	....	....	....	....	....	....	....	....	....	....	....
Scarabæidæ.........	....	1 .01	6 .17	3 .58	2 .18	2 .10	1 .40	8 .33	1 .05	3 .29	....	3 .23	....	....
Anomala binotata	....	....	4 .14	2 .43	....	....	1 .25	3 .17	....	2 .04	....	2 .03	....	....
Elateridæ...........	....	1 .05	3 .03	1 .07	....	....	....	1 .02	....	2 .09	....	2 .07	....	....
Lampyridæ	....	...	....	1 .02	....	....	....	1 .01	....	....	....	....	....	....
Cerambycidæ.......	...	....	3 .02	....	....	....	1 .10	1 .01	....	....	....	....	....	....
Psenocerus supernotatus......	....	....	1 .01	....	....	....	1 .10	1 .01	....	....	....	....	....	....
Chrysomelidæ	....	....	1 †	....	...	....	....	....	...	...	....	....	....	1 .02

TABLES OF THE FOOD — Concluded.

	Orchard Oriole.	Bronzed Grackle.	Total.	King Bird.	Wood Pewee.	Traill's Flycatcher	Yellow-bellied Flycatcher.	Total.	Black-billed Cuckoo.	Red-headed Woodpecker.	Flicker.	Total.	Mourning Dove.	Quail.
Number of Birds.......	2	3	11	3	3	2	1	9	1	4	1	5	1	2
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Rhynchophora	....	1 †	3 .01	....	....	....	....	....	....	....	....	....	...	1 .01
5. *Hemiptera*..........	....	....	1 †	...	....	....	1 .10	1 .01	....	....	....	....	....	....
Homoptera.........	....	....	1 †	....	....	....	....	....	....	....	....	....	....	....
Cydnidæ............	....	...	...	....	....	....	1 .10	1 .01	....	..	....	....	....	...
6. *Orthoptera* (Acrididæ).........	....	....	1 .02	....	....	....	....	....	....	....	....	....	....	....
V. CRUSTACEA (Crawfish).........	....	1 .08	1 .02	....	....	....	....	....	....	..	..	....	....	....
Vegetable Food (Seeds)	....	3 .62	6 .32	....	....	....	....	....	....	2 .20	2 .16	...	1 1.00	2 .96
Leguminosæ........	....	...	...	....	....	....	....	....	....	....	....	..	1 .25	1 .02
Compositæ..........	....	...	...	....	....	....	....	...	....	...	....	....	...	1 .32
Polygonum.........	....	...	2 .01	....	....	....	....	....	....	...	...	....	....	2 .03
Wheat..............	....	....	1 .08	...	....	....	..	....	....	....	....	...	..	...
Setaria.........	....	...	...	....	....	....	....	..	...	..	....	...	...	1 .02
Corn........	....	3 .62	4 22		...	...	...	..	...	2 .20	2 .16	...	1 .75	2 .57

GENERA AND SPECIES RECOGNIZED IN THE FOOD.

The following lists are intended to supplement the preceding tables and, taken together with them, to present all the details concerning the food of the birds observed in the orchard, upon which the foregoing discussion is based. In the first list the genera and species recognized in the food of each kind of bird are given separately ; in the second the food elements are systematically arranged, and against the name of each element the names of all the species of birds are placed in whose food that element was recognized. The figures preceding the names of the birds in the second list indicate the number of individuals in which the given element was found :

TURDIDÆ.

Turdus migratorius · Helix, Hyalina, Limnea humilis, Formica, Nephelodes violans, Anisopteryx vernata, Elaphrus ruscarius, Staphylinus badipes, Aphodius, A. inquinatus, Phyllo-

phaga, Anomala lucicola, A. binotata, Melanotus, Monocrepidius, Graphorhinus vadosus, Alydus eurinus, Cœnus delius, Hymenarcys, Polydesmus serratus, Lumbricus.

Mimus carolinensis: Formica, F. fusca, Lasius, L. niger, Nephelodes violans, Anisopteryx vernata, Clivina striatopunctata, Anisodactylus, Hister americanus, H. perplexus, Onthophagus, Aphodius, A. inquinatus, Phyllophaga, Anomala binotata, Melanotus, Graphorhinus vadosus, Tanymecus confertus, Baris, Sphenophorus, Cœnus delius, Podisus spinosus, Iulus.

Harporhynchus rufus: Anisopteryx vernata, Chlænius, Stenolophus conjunctus, Hister americanus, H. perplexus, Aphodius, Diplotaxis georgiæ, Anomala binotata, Melanotus, Monocrepidius, Baris confinis, Iulus.

SAXICOLIDÆ.

Sialia sialis: Anisopteryx vernata, Anisodactylus baltimorensis, Aphodius, Anomala binotata, Chrysomela suturalis, Diabrotica vittata, Cœnus delius, Hymenarcys æqualis, Euschistus.

PARIDÆ.

Parus atricapillus: Anisopteryx vernata, Psenocerus supernotatus.

TROGLODYTIDÆ.

Troglodytes domesticus: Anisopteryx vernata, Olibrus, Aphodius, Monocrepidius auritus, Psenocerus supernotatus, Blissus leucopterus, Iulus.

MNIOTILTIDÆ.

Helminthophaga peregrina: Anisopteryx vernata, Telephorus bilineatus.

Dendrœca æstiva: Anisopteryx vernata, Aphodius, Telephorus bilineatus, Psenocerus supernotatus.

Dendrœca pennsylvanica: Anisopteryx vernata, Psenocerus supernotatus.

Dendrœca striata: Anisopteryx vernata, Aphodius, Psenocerus supernotatus.

Dendrœca virens: Anisopteryx vernata, Psenocerus supernotatus.

Geothlypis trichas: Anisopteryx vernata, Psenocerus supernotatus, Piesma cinerea.

VIREONIDÆ.

Vireo gilvus: Anisopteryx vernata, Anomala binotata, Telephorus bilineatus, Euschistus.

AMPELIDÆ.

Ampelis cedrorum: Anisopteryx vernata, Aphodius inquinatus, A. femoralis.

HIRUNDINIDÆ.

Petrochelidon lunifrons: Aphodius inquinatus.

FRINGILLIDÆ.

Coturniculus passerinus: Setaria.

Spizella domestica: Anisopteryx vernata, Anomala binotata, Baris, Setaria, Panicum.

Spizella agrestis: Anisopteryx vernata, Onthophagus, Aphodius A. inquinatus, Monocrepidius, Baris, Sphenophorus.

Spiza americana: Helix, Agapestemon, Anisopteryx vernata, Anisodactylus, Ips fasciatus, Aphodius, A. inquinatus, Anomala binotata, Sphenophorus, Wheat, Setaria.

Zamelodia ludoviciana: Anisopteryx vernata, Anomala binotata.

Passerina cyanea: Aphidius, Anisopteryx vernata, Onthophagus, Aphodius, Anomala binotata, Monocrepidius, Baris, Setaria.

ICTERIDÆ.

Molothrus ater: Aphodius, Dibolia aërea, Polygonum, Corn.

Agelæus phœniceus: Nephelodes violans, Anisopteryx vernata, Anomala binotata, Tanymecus confertus, Polygonum, Wheat.

Icterus galbula: Anisopteryx vernata, Anomala binotata, Phymatodes variabilis, Psenocerus supernotatus.

Icterus spurius: Camponotus, Anisopteryx vernata.

Quiscalus purpureus æneus: Calosoma calidum, Dorcus parallelus, Crawfish, Corn.

TYRANNIDÆ.

Tyrannus carolinensis: Anisopteryx vernata, Aphodius inquinatus, Anomala, A. binotata, Melanotus.

Contopus virens: Ips fasciatus, Aphodius, A. inquinatus.

Empidonax trailli: Anisopteryx vernata, Anomala.

Empidonax flaviventris: Aphodius, Anomala binotata, Psenocerus supernotatus, Hymenarcys.

CUCULIDÆ.

Coccyzus erythrophthalmus: Anisopteryx vernata, Anomala.

PICIDÆ.

Melanerpes erythrocephalus: Camponotus, Anisopteryx vernata, Calosoma calidum, Scarites substriatus, Canthon hudsonias, Anomala binotata, Melanotus, Corn.

COLUMBIDÆ.

Zenaidura carolinensis: Corn.

PERDICIDÆ.

Ortyx virginiana: Chrysomela suturalis, Polygonum, Setaria, Corn.

Helix: 1 Turdus migratorius, 1 Spiza americana.

Hyalina: 1 Turdus migratorius.

Limnæa humilis: 1 Turdus migratorius.

Agapestemon: 1 Spiza americana.

Formica sp.: 1 Turdus migratorius, 1 Mimus carolinensis.

F. fusca: 1 Mimus carolinensis.

Lasius sp.: 1 Mimus carolinensis.

L. niger: 3 Mimus carolinensis.

Camponotus: 1 Icterus spurius, 1 Melanerpes erythrocephalus.

Aphidius: 1 Passerina cyanea.

Nephelodes violans: 3 Turdus migratorius, 1 Mimus carolinensis, 1 Agelæus phœniceus.

Anisopteryx vernata: 3 Turdus migratorius, 8 Mimus carolinensis, 2 Harporhynchus rufus, 1 Sialia sialis, 2 Parus atricapillus, 3 Troglodytes domesticus, 1 Helminthophaga peregrina, 5 Dendrœca æstiva, 2 Dendrœca pennsylvanica, 4 Dendrœca striata, 1 Dendrœca virens, 1 Geothlypis trichas, 3 Vireo gilvus, 7 Ampelis cedrorum, 2 Spizella domestica, 1 Spizella agrestis, 10 Spiza americana, 1 Zamelodia ludoviciana, 17 Passerina cyanea, 1 Agelæus phœniceus, 3 Icterus galbula, 2 Icterus spurius, 2 Tyrannus carolinensis, 1 Empidonax trailli, 1 Coccyzus erythrophthalmus, 1 Melanerpes erythrocephalus.

Elaphrus ruscarius: 1 Turdus migratorius.

Clivina striatopunctata: 1 Mimus carolinensis.

Calosoma calidum: 1 Quiscalus purpureus æneus, 1 Melanerpes erythrocephalus.

Scarites substriatus: 1 Melanerpes erythrocephalus.

Chlœnius: 1 Harporhynchus rufus.

Anisodactylus sp.: 1 Mimus carolinensis, 1 Spiza americana.

A. baltimorensis: 2 Sialia sialis.

Stenolophus conjunctus: 1 Harporhynchus rufus.

Staphylinus badipes: 1 Turdus migratorius.

Ips fasciatus: 1 Spiza americana, 1 Contopus virens.

Olibrus: 1 Troglodytes domesticus.

Hister americanus: 1 Mimus carolinensis, 1 Harporhynchus rufus.

H. perplexus: 1 Mimus carolinensis, 1 Harporhynchus rufus.

Dorcus parallelus: 1 Quiscalus purpureus æneus.

Canthon hudsonias: 1 Melanerpes erythrocephalus.

Onthophagus: 1 Mimus carolinensis, 1 Spizella agrestis, 1 Passerina cyanea.

Aphodius sp.: 1 Turdus migratorius, 1 Mimus carolinensis, 1 Harporhynchus rufus, 1 Sialia sialis, 1 Troglodytes domesticus, 1 Dendrœca æstiva, 1 Dendrœca striata, 1 Spizella agrestis, 3 Spiza americana, 1 Passerina cyanea, 1 Molothrus ater, 2 Contopus virens, 1 Empidonax flaviventris.

A. inquinatus: 1 Turdus migratorius, 1 Mimus carolinensis, 2 Ampelis cedrorum, 1 Petrochelidon lunifrons, 1 Spizella agrestis, 1 Spiza americana, 1 Tyrannus carolinensis, 1 Contopus virens.

A. femoralis: 1 Ampelis cedrorum.

Diplotaxis georgiæ: 1 Harporhynchus rufus.

Phyllophaga: 1 Turdus migratorius, 3 Mimus carolinensis.

Anomala sp.: 1 Tyrannus carolinensis, 2 Empidonax trailli, 1 Coccyzus erythrophthalmus.

A. lucicola: 1 Turdus migratorius.

A. binotata: 3 Turdus migratorius, 10 Mimus carolinensis, 2 Harporhynchus rufus, 4 Sialia sialis, 1 Vireo gilvus, 2 Spizella domestica, 2 Spiza americana, 1 Zamelodia ludoviciana, 4 Passerina cyanea, 1 Agelæus phœniceus, 3 Icterus galbula, 2 Tyrannus carolinensis, 1 Empidonax flaviventris, 2 Melanerpes erythrocephalus.

Melanotus: 1 Turdus migratorius, 1 Mimus carolinensis, 1 Harporhynchus rufus, 1 Tyrannus carolinensis, 1 Melanerpes erythrocephalus.

Monocrepidius: 1 Turdus migratorius, 1 Harporhynchus rufus, 1 Spizella agrestis, 1 Passerina cyanea.

M. auritus: 1 Troglodytes domesticus.

Telephorus bilineatus: 1 Helminthophaga peregrina, 1 Dendrœca æstiva, 1 Vireo gilvus.

Phymatodes variabilis: 1 Icterus galbula.

Psenocerus supernotatus: 1 Parus atricapillus, 2 Troglodytes domesticus, 3 Dendrœca æstiva, 2 Dendrœca pennsylvanica, 3 Dendrœca striata, 1 Dendrœca virens, 1 Geothlypis trichas, 1 Icterus galbula, 1 Empidonax flaviventris.

Chrysomela suturalis: 1 Sialia sialis, 1 Ortyx virginiana.

Diabrotica vittata: 1 Sialia sialis.

Dibolia aërea: 1 Molothrus ater.

Graphorhinus vadosus: 1 Turdus migratorius, 1 Mimus carolinensis.

Tanymecus confertus: 1 Mimus carolinensis, 1 Agelæus phœniceus.

Baris: 1 Mimus carolinensis, 1 Spizella domestica, 1 Spizella agrestis, 1 Passerina cyanea.

B. confinis : 1 Harporhynchus rufus.

Sphenophorus : 1 Mimus carolinensis, 1 Spizella agrestis, 1 Spiza americana.

Piesma cinerea : 1 Geothlypis trichas.

Blissus leucopterus : 1 Troglodytes domesticus.

Alydus eurinus : 1 Turdus migratorius.

Cœnus delius : 1 Turdus migratorius, 1 Mimus carolinensis, 1 Sialia sialis.

Hymenarcys : 1 Turdus migratorius, 1 Empidonax flaviventris.

H. æqualis : 2 Sialia sialis.

Euschistus : 1 Sialia sialis, 1 Vireo gilvus.

Podisus spinosus : 1 Mimus carolinensis.

Polydesmus serratus : 1 Turdus migratorius.

Iulus : 1 Mimus carolinensis, 1 Harporhynchus rufus, 1 Troglodytes domesticus.

Crawfish : 1 Quiscalus purpureus æneus.

Lumbricus : 1 Turdus migratorius.

Polygonum : 1 Molothrus ater, 1 Agelæus phœniceus, 2 Ortyx virginiana.

Wheat : 1 Spiza americana, 1 Agelæus phœniceus.

Setaria : 1 Coturniculus passerinus, 2 Spizella domestica, 1 Spiza americana, 1 Passerina cyanea, 1 Ortyx virginiana.

Corn : 1 Molothrus ater, 3 Quiscalus purpureus æneus, 2 Melanerpes erythrocephalus, 1 Zenaidura carolinensis, 2 Ortyx virginiana.

Panicum : 1 Spizella domestica.

THE FOOD RELATIONS OF THE CARABIDÆ AND COCCINELLIDÆ.

BY S. A. FORBES.

A group or association of animals or plants is like a single organism in the fact that it brings to bear upon the outer world only the surplus of forces remaining after all conflicts interior to itself have been adjusted. Whatever expenditure of energy is necessary to maintain the existing internal balance amounts to so much power locked up, and rendered unavailable for external use. In many groups this latent energy is so considerable and is liable to such fluctuations, that a knowledge of its amount and kinds, and of the laws governing its distribution, is extremely important to one interested in measuring or foreseeing the sum and character of the outward-tending activities of the class.

This seems especially true of the insect world. If the checks upon the multiplication of insects and upon their average length of life which are due to insects themselves were to be suddenly removed, there is much reason to suppose that the total external effect of the class would be very greatly intensified, at least for a time.

Whether our purpose be merely to understand the internal economy of insect life as a part of the general system of nature, or to apply such knowledge to a regulation of the depredations of insects upon plants and animals, it is equally necessary that we should know the character and extent of the conflicts which prevail within the class, and should understand how the various subordinate groups limit each other's numbers and activity, either indirectly by competition, or directly by destruction.

The following notes are a contribution to a more exact knowledge of this subject than has hitherto prevailed. The view of the functions of the two principal predaceous families of Coleoptera (Carabidæ and Coccinellidæ) which is common among

entomologists, is largely due to a hasty generalization, based upon insufficient data. Observations of the food of these beetles have hitherto been left almost wholly to chance, and have nowhere been systematically pursued—from which it has resulted that we know their habits only in the most conspicuous situations, and have not a fair idea of the general average of their food. Neither have observations of any kind been numerous enough to enable us to detect clearly differences of food habit in different species or genera of these families; but, with slight occasional exceptions, all Carabidæ and Coccinellidæ have been classed together as essentially carnivorous.

Besides insufficient observation, a tendency to reason too confidently from structure to function is responsible for many mistaken notions—a tendency particularly liable to mislead when applied to the habits of animals. It is frequently assumed that the most prominent and peculiar adaptive structures are necessarily indicative of the most important and customary habits, and that structures especially fitted for one function are thereby incapacitated for every other.

The first of these assumptions ignores the fact that many adaptive structures are acquired for the sake of the advantage derived, not in ordinary, but in extraordinary circumstances. The struggle for existence is one of greatly varying intensity, and the really decisive moments of the conflict are often only brief and occasional. The time spent in actual combat by very belligerent and very powerful animals, is doubtless but a small fraction of their whole lives; and yet by far the most prominent and important of the structural peculiarities which serve to distinguish them from their more peaceful allies, may be those which enable them to triumph in these occasional but critical instants. Likewise the pinch of starvation must commonly be felt only at rare intervals, but no structures will be more thoroughly elaborated or carefully preserved than those serving to give the animal the advantage during these brief periods, since the continued existence of the species depends on these no less than on those of constant use. From the prominent adaptive structures we may safely infer, as a general rule, what the animal will do in the stress of a life and death struggle, but not necessarily what are its ordinary practices.

The second of the above assumptions is also negatived, occa-

sionally, at least, by the principles of natural selection, especially as applied to the machinery of food prehension. Whatever departure from the primitive vegetarian habit of animals any group has acquired, was of course initiated to enable it to draw on other food resources than those previously open to it. But as animal food is usually less abundant and less generally distributed than vegetable, it would not, at first, be to the advantage of any that they should become exclusively dependent upon the former; their interests would be best served by such modifications of structure and habit as would enable them to draw upon one or the other store, according to circumstances. Acquiring some power to capture and masticate animal food, they would not wholly lose that of appropriating vegetable food also; and however well fitted their prehensile and digestive organs might become for the former function, we should expect that they would not altogether lose their fitness for the latter. It would be only as competition on this higher plane increased to the pressure point, that a few members of the differentiating group would be forced to the highest plane of complete dependence on animal food alone.

The first results of an attempt at a more exact and exhaustive investigation of this subject, were given by the writer in a brief paper published in Bulletin 3 of this series, in November, 1880.* In another paper by Mr. F. M. Webster in the same Bulletin,† a summary of previously recorded observations was given, together with many additional and original field notes. A few other items have since been published by others, but confined, as far as known to me, to chance observations on single insects.

The method here followed, as in the paper above mentioned, has been that of dissection. The alimentary canals of beetles taken in a great variety of situations, at various seasons and at different times of day, have been removed, placed in glycerine on microscope slides, and opened with small knives and mounted needles, so as to display the contents completely. These have then been studied with whatever power of the microscope was necessary, and mounted as microscope slides for permanent preservation and repeated examination. The amount of information

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**Notes on Insectivorous Coleoptera.* By S. A. Forbes. Illinois State Laboratory of Natural History, Bulletin No. 3, pp. 153–160.

†Pp. 149–152.

which could thus be acquired by patient study, was often quite surprising. While it was of course rarely possible to distinguish species, or even genera, all the fragments could usually be classified with some fair degree of definiteness; and there was commonly no difficulty in making satisfactory estimates of the ratios of the different food elements present.

In some of the most important cases, the facts elicited were of the highest degree of exactness. Several collections of predaceous beetles were made in situations where some particular species of noxious insect was especially abundant, with a view to determining to what extent the latter was preyed upon by its supposed enemies. In such cases it was not difficult to tell with certainty, even from very minute fragments, whether the given insect had been eaten or not. Even where no solid structures were present, and the contents of the alimentary canal were entirely fluid, it was still usually possible to say whether these fluids had an animal or a vegetable origin. After many observations and some experiments, it was found that partially digested animal food in the stomach of a beetle was commonly bathed in a black juice, which, when examined under a high power of the microscope, was seen to contain nothing but a minutely divided flocculent matter, probably composed of irregular aggregations of fat droplets and other organic particles. This fluid was never found in connection with purely vegetable contents, but sometimes filled the stomach alone, and contained nothing to indicate its origin. In all the latter class of cases I have regarded it as proof that the food had been derived from animal sources, probably usually consisting of the juices of insects recently captured.

For the determinations of the fungi mentioned herein, I am indebted chiefly to Prof. T. J. Burrill, of the Industrial University at Champaign.

The insects dissected for this paper were partly obtained in the course of miscellaneous collecting, and partly secured for me especially for the purpose, by one of my entomological assistants, Mr. F. M. Webster, who kept careful notes of the situations in which the specimens were taken, the hour of the day when they were captured, and the objects upon which it seemed probable that they had lately fed. Examples of the latter were also frequently bottled with the specimens, for comparison. The special

collections from the orchard infested by canker-worms, and the corn-fields at Jacksonville and Normal overrun by chinch-bugs, were made by myself.

In the following discussion, each genus is taken up separately, and the details of its food are given both under general circumstances, as shown by specimens from miscellaneous situations, and also under the various peculiar conditions illustrated by the special collections, made for the purpose of exhibiting the food of these insects as related to particularly injurious species, and these are followed by a summary and discussion of the food of each family, taken as a unit. The tables exhibit, first, the food of the family under ordinary circumstances; second, under peculiar conditions; and, third, under all the circumstances, taken together.

FAMILY CARABIDÆ.

My notes upon the food of this family are derived from the dissection and study of one hundred and seventy-five specimens, representing thirty-eight species and twenty genera. Eighty-two specimens were collected in miscellaneous situations, twelve were taken in a field infested by cabbage-worms, ten in a corn-field overrun by chinch-bugs, and seventy-one in an orchard which was being destroyed by canker-worms. The first collection of eighty-two specimens from various situations represented thirty-two species, belonging to eighteen genera. They were obtained in different parts of the State, from DeKalb County in the north to Union in the south, and at all seasons of the year, from April to October; and doubtless represent fairly well the food of the family in Illinois during the entire year. The collections illustrating the food of the Carabidæ as related to the cabbage-worm were made in a field of young plants at Normal, Ill., in April, 1882, where the larvæ of *Agrotis annexa* were abundant and destructive. The collection showing the food of this family in the presence of the chinch-bug, consisted of ten specimens of a single species found in July, 1882, very abundant about the roots of corn in a field where the bases of the stalks were largely covered by young chinch-bugs. The third special collection consisted of seventy-one insects, representing nineteen species, obtained in May of two successive years (1881 and 1882) in an

orchard which had been infested for several years with the canker-worm to such an extent as to cause the total destruction of a large part of the trees.

Genus Calosoma.

This genus is represented by three specimens of *C. scrutator*, collected in the orchard with the canker-worms, and by nine of *C. calidum*, which were variously distributed. The *C. scrutator* was found to have eaten only animal food, about two-thirds of which was recognizable as of insect origin. The remaining third was due to the occurrence of liquid animal food, or the fluid to which I have given this interpretation. In the stomach of one of the beetles the insect food consisted only of minute particles of a reddish brown crust which it was impossible to classify further. A single *C. calidum*, taken in May in Central Illinois, contained only liquid animal food. Seven specimens, taken in the orchard above-mentioned, had likewise fed upon animal food alone, forty per cent. recognizable as insects, and the remainder not otherwise determinable. As far as can be judged from the contents of the alimentary canal in these thirteen specimens, the species of this genus are strictly carnivorous, and have the habit either of sucking the juices of their prey, or of selecting only those parts most easily masticated, reducing these to indistinguishable fragments. Certainly there was not the slightest trace of vegetable food in any of these beetles.*

Genus Scarites.

Two specimens of *S. subterraneus*, taken in 1882, one at Normal and the other at Anna, in Southern Illinois, had eaten only animal food, one-half of which was unrecognizable, and the remainder insects. Four specimens of the same species, taken in the cabbage-field, have a precisely similar record.

These nineteen specimens, belonging to three species, were the only examples of *Carabidæ proper* whose food was studied, and all agreed in a strictly carnivorous character.

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*Mr. F. M. Webster has seen a *C. calidum* eating a small grasshopper.

Genus Brachynus.

A single specimen of *Brachynus fumans*, caught in Central Illinois, in May, had taken only liquid animal food.

Genus Galerita.

Seventeen specimens of *Galerita janus*, four collected in various situations, and thirteen in the orchard in Tazewell County, had made a much more varied record. All of the group first mentioned had eaten insects, which amounted to eighty-eight per cent. of their food, nearly all caterpillars of undetermined species. The remaining twelve per cent. consisted of vegetable food eaten by two of the specimens, and was apparently derived chiefly from the seeds of grass. A larger ratio of animal food is noticed in the thirteen taken where canker-worms abounded. Here vegetation amounted to only six per cent., all of exogenous origin, as shown by the branching bundles of spiral cells in the vegetable fragments noticed, while the animal food amounted to ninety-four per cent. Insects stand at eighty-five per cent., seven per cent. being Diptera, one per cent. unrecognizable insect larvæ, and the whole of the remainder caterpillars. The last were nearly all easily determined as canker-worms, which amounted to a little over half the food. Seven individuals of the thirteen had eaten these worms. Five per cent. of the food (taken by three of the specimens) consisted of spiders, and four per cent. (taken by a single specimen) was animal food, not otherwise determinable. The remains of a caterpillar in the stomach of a single beetle were clearly distinguished as those of a noctuid larva (cutworm).

If from the ratios of animal food taken by the examples from the orchard we subtract the ratio of canker-worms (fifty-two per cent.) the remainder is just seven times the ratio of vegetation eaten. Recalling the percentages of animal and vegetable food taken by the four specimens first mentioned, we find that here also the former is almost exactly seven times the latter. This shows beyond question that the canker-worms eaten were *in addition* to the ordinary ratio of animal food taken by this species under the usual conditions.

Genus Loxopeza.

Three specimens of this genus were studied, all belonging to the species *L. atriventris*, collected in July and September in Northern and Central Illinois. One of these had eaten immense numbers of minute, oval, binucleate cells, determined by Prof. Burrill as spores of Sphæronemei, probably Phoma, a fungus which forms small black specks upon dead wood, stems of weeds, etc. A second specimen had eaten some undetermined insect, and about equal quantities of three elements, namely: the above spores of Phoma and pollen and anthers of grass,—doubtless blue grass, upon which the insect was taken. A few spores of Helminthosporium were likewise noticed. The crop of a third specimen, taken at Normal, was distended with an oily liquid, but contained nothing else except a few spores of Helminthosporium. This specimen had probably been sucking the juices of some insect. The ratios of animal and vegetable food, as nearly as I could estimate them, were as forty-four to fifty-six. A specimen of this species, captured in the orchard, had not recently taken food.

Genus Calathus.

Six examples of *C. gregarius*, three from DeKalb County and three from the orchard, are the only representatives of this genus. One-third of the food of those first mentioned consisted of caterpillars, a second third of other insect larvæ, and the remainder of the pollen of grass. The food of the second group was extremely similar, a third consisting, as before, of vegetation, another third of canker-worms, and the remainder of insect fragments not further determinable.

Genus Platynus.

The stomach of a single *P. decorus*, taken in the orchard, contained only liquid animal food. Two examples of *P. limbatus*, both from Southern Illinois, in April, had derived about four-fifths of their food from the vegetable kingdom, partly seeds of grass and partly the parenchyma of exogenous plants. The remainder consisted entirely of Aphides (plant-lice). These specimens were doubtless too few to give a correct idea of the average food of the genus as a whole.

Genus Evarthrus.

Five specimens of *E. colossus*, taken at various dates and places, had derived about one-tenth of their food from endogens, and the remainder wholly from insects. Twenty per cent., eaten by one of the beetles, was recognized as caterpillars. Scarabæidæ are credited with another twenty per cent., and undetermined larvæ of Coleoptera with about an equal ratio. Minute quantities of fungi were noticed in the stomachs of two of these beetles, and traces of undetermined Algæ in one.

Two examples of *E. sodalis*, taken in the Tazewell County orchard, had consumed only insects, all canker-worms, except traces of an ant and a single gnat.

The insect ratio of the genus as represented by these seven specimens, stands at ninety-three per cent.

Genus Pterostichus.

Thirteen specimens were dissected, representing *P. permundus*, *P. sayi*, and *P. lucublandus*.

The number of each species is not sufficient to give distinctive food characters, and the genus may therefore best be treated as a whole. Seven of the specimens, taken in miscellaneous situations in Central Illinois in April, May, and September, had found about one-fourth of their food in the vegetable kingdom, about one-third of which consisted of undetermined fungi, and the remainder chiefly of exogenous plants. A few spores of Helminthosporium, probably accidental, were noticed in the stomach of a single beetle. Forty-three per cent. of the food consisted of insects, among which Hymenoptera only were recognized. A single mite occurred in one of the beetles. Three specimens taken in the orchard infested by canker-worms, had eaten endogenous vegetation, to the amount of about one-fifth of their food. Caterpillars made eleven per cent., and undetermined insects two per cent., the remaining ratio being accounted for by the presence of liquid animal food. Two-thirds of the contents of three specimens taken among the cabbages, consisted of animal matter, half of which was clearly recognized as the larvæ of *Agrotis annexa* infesting the field. The remaining third, composing the

entire food of one of the beetles, consisted wholly of fragments of grass.*

Genus Amara.

Six specimens of this genus were dissected, three of *A. carinata*, one of *A. angustata*, and two of *A. impuncticollis*. Three specimens of *A. carinata*, taken in Southern Illinois in April, 1882, had eaten only vegetation, partly derived from graminaceous plants, and partly consisting of seeds and exogenous tissues. About one-fourth of the food was recognizable as fungi, chiefly of the genus Peronospora. Ninety per cent. of that of a single *A. angustata*, taken in June, consisted of mites, the remainder being fragments of grass. An *A. impuncticollis*, taken in the orchard with the canker-worms, had eaten only vegetable food, chiefly undetermined, but with traces of fungi. Another of the same species from the cabbage field, had derived its food about equally from plant and animal sources, that from the former consisting chiefly of grass.

Genus Dicælus.

Three examples of *Dicœlus elongatus* had taken only animal food, as indicated by the fluid contents of the stomachs. One of these was found in the orchard, and the other in Central Illinois.

Genus Chlænius.

This genus is represented by twenty-three individuals, the next to the largest number studied of any genus of Carabidæ. Six examples from Southern Illinois, collected from April to September, belong to the species *C. diffinis*, *C. nemoralis*, and *C. tomentosus*. The animal food of these was about three times the vegetable. Two-thirds consisted of insects, of which caterpillars alone were determinable; and earth-worms eaten by one of the beetles made about eight per cent. More than half the vegetable food consisted of fungi, which included fourteen per cent. of some fleshy fungus, apparently Coprinus, together with spores of Dematiei. Fragments of exogenous plants were recognized in one of the beetles. A single *C. diffinis*, taken among the cab-

*A specimen of *P. lucublandus* was seen by Mr. F. M. Webster making a meal from a dead *P. sayi*.

bage-worms, had eaten only insects, chiefly a caterpillar, and a larva of a beetle. A mere trace of endogenous vegetation was also detected. Of sixteen specimens collected among the canker-worms, three were *C. erythropus*, and thirteen *C. diffinis*. Cut-worms made about one-third of the food of the first, and earth-worms the remaining two-thirds. The latter were easily distinguishable by the peculiar spines mixed with dirt in the stomachs of the beetles. About ninety per cent. of the food of the other species was of animal origin, and about half the vegetable food was fungi. Insects made seventy-two per cent., nearly half caterpillars, of which the greater part (thirty-one per cent.) was canker-worms. Fragments of a fly were observed in one of the beetles, and another had eaten one of the *Telephoridæ*. Mites and myriapods (Geophilus) had also been devoured by one.

Genus Agonoderus.

Fifteen specimens of Agonoderus were studied, ten of which were those already referred to as representing the food relations of these beetles to the chinch-bug. Fragments of that insect amounted to about one-fifth the food of all, and were found in four of the beetles; and plant-lice, taken by half that number, amounted to about eight per cent. A single ant, *Lasius flavus*, eaten by one, was rated at five per cent.; and other insects brought the general average of the class up to thirty-five per cent. Vegetation made just half the food, all fragments of the higher plants except one per cent. each of Helminthosporium and Peronospora. A single Agonoderus, taken among the cabbages, had eaten only undeterminable ~~animal~~ vegetable food. Four specimens from various situations had made a similar record, differing only by the presence of a few mites in the stomach of one of the beetles. Eleven per cent. of fungi, taken by the group last mentioned, was derived from Ramularia and Coleosporium. The circumstances of capture, together with the contents of the stomach of one of these beetles, indicated that it had made its meal chiefly from the seeds of June grass, but the remainder of the vegetable food could not be more definitely classified.

Genus Anisodactylus.

This large and abundant genus is represented by thirty-one specimens, belonging to six species. Five specimens of *A. rusticus* were examined, captured in McLean and DeKalb Counties in May, June, and July. Two of these had taken only liquid animal food, but the remaining three had eaten no animal matter at all. Among the fungi found, Cladosporium and Peronospora were recognized, and fragments of Hepaticæ were noted in two of the beetles. Two specimens of *A. harrisi*, taken in Union County in April, 1882, had eaten only vegetation, all seeds of grass and of other plants. A single *A. discoideus* from McLean County in June, contained nothing but liquid food. Seven examples of *A. baltimorensis*, widely distributed in time and place, had derived only about fourteen per cent. of their food from the animal kingdom, all taken by one of the beetles, whose stomach contained only chyme. About half of the eighty-six per cent. of vegetation, composing the entire food of the remaining six specimens, was demonstrably obtained from the seeds of June grass, upon which several of the insects were taken. Two examples of *A. sericeus* from Northern Illinois had made about three-fourths of their food of grass, and the remainder of unrecognizable insects. In the stomachs of two specimens of *A. opaculus*, fragments of seeds and other vegetation were the only objects found.

Taking together the nineteen specimens of this genus above mentioned, collected in various places, we find that animal food made about one-fourth of the total, and that the vegetation as far as recognized was chiefly derived from June grass and other graminaceous plants.

The record of ten specimens taken from the canker-worm orchard, is not especially different from that of the foregoing group. Only one of these had eaten animal matter at all, ninety per cent. of the food of this consisting of undetermined Diptera. Here, again, the recognizable vegetation was chiefly graminaceous, only ten per cent. being clearly derived from exogenous plants. Two specimens from the cabbage field afford no occasion for special remark. The stomach of one was distended with liquid animal food; that of the other contained vegetation only.

Genus Amphasia.

Four examples of *A. interstitialis* indicated that this species is almost strictly vegetarian, only three per cent. of the food consisting of insects. Of the remaining ninety-seven per cent., little can be said except that it was certainly of vegetable origin.

Genus Bradycellus.

A single specimen of *B. dichrous* had eaten only insects, which could not be further classified.*

Genus Harpalus.

Nineteen specimens of Harpalus were studied, belonging to the three species *caliginosus*, *pennsylvanicus*, and *herbivagus*. Two individuals belonging to the first of these species, from Normal and Towanda in August and September, had taken about one-tenth of their food from insects (caterpillars and Diptera). Twenty per cent. of unrecognizable animal food and five per cent. of mites bring the general average up to thirty-five per cent. The sixty-five per cent. of vegetation eaten consisted chiefly of tissues of grass. A little pollen of Compositæ, and other exogenous structures were likewise recognized. Three per cent. was fungi, all spores of Helminthosporium. Seven specimens of *H. pennsylvanicus*, caught in Northern, Central, and Southern Illinois, in April, August, and September, had taken about one per cent. of their food from the animal kingdom. This included an ant eaten by one of the beetles, and a few mites taken by another. About half the vegetable food was not further recognizable. Twenty-nine per cent. was the pollen of rag-weed, taken by two beetles captured upon that plant, and fourteen per cent. was derived from June grass. Fungi made eight per cent. of the food of these beetles, a little of it Helminthosporium, but chiefly Peronospora. Three examples of *H. herbivagus*, taken in Northern Illinois, had eaten only vegetation, about one-third of it graminaceous, and another third fungi. Only seven per cent. of the food of the above twelve specimens of this genus, taken from

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*Mr. Webster reports a specimen of *B. rupestris* taken in 1881 in the act of devouring an earth-worm.

ordinary situations, consisted of animal food, of which a little less than half was insects. Fungi made thirteen per cent., and the remaining vegetable food was about equally divided between grasses and exogenous plants. Three specimens of *H. caliginosus* and *H. pennsylvanicus*, taken among the canker-worms, had derived one-third of their food from those caterpillars, while the other two-thirds consisted of vegetation, sixteen per cent. being Peronospora, and the remainder chiefly seeds and exogenous tissues. Four specimens of *H. herbivagus*, collected in the cabbage field, in April, had eaten none of the cabbage-worms, and only ten per cent. of insects (Diptera). The remainder of the food consisted apparently of fragments of seeds, as indicated by the contents of the cells of the fragments and by other microscopic characters. A piece of the epidermis of grass was noticed in one of the beetles. Taking the genus Harpalus as a whole, as far as these nineteen specimens can be supposed to indicate its food, we find that only about one-eighth of it consisted of animal substances. Insects stand at nine per cent., two-thirds of them caterpillars,—ants and Diptera making up the balance. Among the items on the vegetable side of the account, we find fungi and pollen of Compositæ each eleven per cent. and seeds and other tissues of grasses, fourteen per cent.

Genus Patrobus.

Two specimens of *P. longicornis*, one from Central and the other from Southern Illinois, had eaten nearly twice as much vegetation as animal food. The latter consisted chiefly of caterpillars, and included in fact nothing else but traces of plant-lice, eaten by one of the two. A little of the vegetation was derived from grass, but the source of the remainder could not be satisfactorily traced.

The Family as a Unit.

We have now to treat the various collections of Carabidæ upon which this paper is based, as distinct and unbroken groups, without reference to the genera of which they are composed. The eighty-three specimens of all the species obtained in miscellaneous situations, are found to have derived forty-two per cent. of their food from the animal kingdom, while the seventy specimens

captured in the orchard so often mentioned took seventy-seven per cent. of their food from the same sources. The individuals from the cabbage field, however, show no such excess of animal food as those just mentioned, the ratios standing for them at forty-one per cent. If we seek to account for this striking surplus shown by the second group, we shall find, in the first place, a difference of more than sixteen per cent. between the ratios of insects eaten by the first and second groups respectively—a fact clearly due to the presence of canker-worms where the second group was collected. This species was eaten by sixteen of the seventy beetles, and composed about one-fifth of the contents of all the alimentary canals. This accounts, however, for only about half the difference noted, the remainder appearing in the larger ratios of the other insects, of mollusks, of earth-worms, and of undetermined animal food.

This indicates either that other forms of animal life than the canker-worms were superabundant in the orchard, or else that the miscellaneous collections do not correctly represent the ordinary food of the Carabidæ. The truth probably lies between the two. The extraordinary wetness of the season, together with the amount of rubbish on the ground in the orchard, gave these beetles an unusual opportunity to capture slugs and earth-worms, and afforded excellent harborage for all sorts of insects. On the other hand, many of the beetles from other situations were preserved especially for dissection because the circumstances of their capture made it seem probable that they were feeding upon vegetation.

These tables indicate one interesting and important fact with regard to the preferences of this family, namely, that where an extraordinary abundance of any kind of animal food appeared, with a consequent increase in the percentage of that kind appropriated by the beetles, this increase was compensated, not by a decrease in the other animal elements, but in the ratios of vegetation only—a fact which clearly shows that the preferences of the Carabidæ are for animal food. It should be noticed, however, that this argument does not apply to all the genera, as is seen, for example, by recalling the record of Anisodactylus. The ten specimens of this genus taken in the orchard had eaten much more vegetation than the nineteen from various other places.

The combination of these various tables into the final one given will tend to correct the deficiencies of the separate exhibits, and the averages of that table will consequently be found to represent more closely the general food of the family than either of the others.

Continuing the comparison of the three separate tables, we find that the beetles represented by the first had taken insects to the amount of twenty-six per cent.; that those from the orchard had about doubled this ratio; while those from the cabbage field fell a little short of it. This last fact is probably related to the time of the year when these beetles were taken—the middle of April in a very late spring, when insect life in general was but just beginning to stir abroad. The ratios of Diptera, Coleoptera, and Hemiptera, were but trivial in all these groups, and not worth separate mention. The extraordinary difficulty of determining the elements of the vegetable food from the minute fragments found in the stomachs of these beetles, makes it impossible to enter into much detail with respect to this. The miscellaneous collections and those from the cabbage field had found a little over half their food in the structures of plants, while those from the orchard had obtained from this source somewhat less than a quarter. Pollen of exogenous plants, which will be found to form so large a ratio of the food of the family next to be considered, appeared here only in three of the specimens, and amounted to but three per cent. of the entire food of the first group. These beetles fed much more largely on graminaceous plants, the recognizable tissues of which amounted to about seventeen per cent. in the first group, and eight in each of the special collections. Fungi were reckoned at about one-tenth of the food of the beetles included in the first collection, and only two per cent. of those from the orchard. The spores of the omnipresent Helminthosporium make the most important contribution to this element of the food, but a number of other genera were recognized.

A few words will suffice for the final table, summarizing the data relating to all the collections, from whatever source derived. This table presents the ratios from one hundred and seventy-five specimens, and as already remarked, a little over half the food of all consisted of animal matter, about one-third being insects,

while mollusks, earth-worms, myriapods and Arachnida make up the remainder.

All orders of insects are represented on the list, with the exception of Orthoptera and Neuroptera. The ratios of none of these are of any special importance, except that of the Lepidoptera, which stands at fifteen per cent. Hymenoptera and Diptera are each one per cent., and Coleoptera and Hemiptera each two. Among the Coleoptera, only Scarabæidæ and Telephoridæ were recognized; among the Hymenoptera only a single ant; and among the Hemiptera, plant-lice and chinch-bugs only. About half the vegetable food could be distinguished as exogenous or endogenous, the remainder being of too indefinite a character to be assigned to either class. As far as known, the endogenous food was more than twice as abundant as the exogenous, and consisted almost wholly of grass or grass-like plants. The fungi, which make somewhat more than a fourth of the food, require no further special mention.

If, discarding the ratios given above, we look only to the number of specimens in which the various food elements are detected, we reach similar results. One hundred and seventeen individuals of the one hundred and seventy-five represented by this final table had eaten animal food, and ninety-seven had taken vegetation. Insects were recognized in eighty-two, Lepidoptera in thirty-one (about one-half of which had eaten canker-worms), Diptera and Coleoptera in nine and four respectively, and Hemiptera in seven. Earth-worms were found in five, myriapods (Geophilus) in but one, and Arachnida (mites and spiders) in nine. Grass-like plants were taken by thirty-six, and fungi by twenty-nine.

Scanning the totals for each genus on this final table, a few results are noted which are worthy of special remark. First, we observe that at least two very abundant genera, represented by specimens enough to give us a fair probability that the average food is correctly exhibited, can hardly be classed as carnivorous insects at all, namely, Harpalus, with its nineteen specimens and twelve per cent. of animal food, and Anisodactylus, with its thirty-one specimens and twenty-one per cent. of the same. Amara and Amphasia should probably be placed in the same category, six specimens of the first and five of the second having taken but twenty-three per cent. and seven per cent., respect-

ively, of food of animal origin. The excessively abundant Agonoderus ranks but little higher as a carnivorous insect, fifteen examples having derived only about one-third of their food from animal sources. On the other hand, twenty-three specimens of Chlænius, and seventeen of Galerita had taken about nine-tenths of their food from insects, mites, myriapods and earth-worms. Thirteen specimens of Pterostichus had obtained three-fourths of theirs from similar sources, while Evarthrus and Calathus, represented by seven and six specimens respectively, had averaged ninety-three per cent. and sixty-seven per cent.

The fact has already been alluded to that the Carabidæ proper had eaten only animal food, and that nearly all this was of a fluid character.

Second, we find the Carabidæ dividing into at least three tolerably distinct groups as respects their food: first, those which seem usually to seize their prey and suck its juices, and take vegetation rarely, if at all; second, those which take a much larger ratio of animal food than of vegetable, but masticate and swallow it, as a rule, including indigestible fragments; and third, those whose habit is essentially vegetarian, but which still take solid animal food in diminished ratios. A fourth group, consisting of Lebia and its allies, is perhaps obscurely indicated by the facts relating to the three specimens of *Loxopeza atriventris* studied. This will probably be found to feed largely upon pollen and fungus spores, after the manner of the Coccinellidæ; and the fossorial Carabidæ will, perhaps, constitute a fifth.

If we look now to the structures of these beetles for some explanation of their differences of habit, we shall find corresponding variations in the form and structure of the mandibles. Where the mandibles are long and curved, and are destitute of basal molar processes, but are provided at or near the middle of the cutting edge with processes relatively long and sharp, the beetle seems to feed substantially upon soft or liquid animal food. If they are of medium length, somewhat slender, broad at base and tapering distally, with the tip acute, and provided with basal processes which are not especially prominent or sharp, the food is chiefly animal, but solid structures are masticated and swallowed, and some vegetation appears in the alimentary canal; while, finally, if they are short and quadrate, blunt at the tips, and provided either with strong

basal processes or broad opposed surfaces, vegetable food is found to predominate. Calosoma is an example of the first of these classes, Chlænius of the second, and Anisodactylus of the third. The seeming exceptions to this generalization shown by the tables at the close of the paper, are found among those genera of which too few specimens have been studied to warrant general conclusions respecting their food.

FAMILY COCCINELLIDÆ.

This family shares with the preceding the credit of limiting the multiplication of other insects, but was shown in the Bulletin of the Laboratory previously mentioned, apparently to depend largely while in the adult stage upon fungi and other vegetable food. The notes in the paper mentioned referred, however, to so small a number of specimens as to make this conclusion of doubtful value. Numerous dissections of Coccinellidæ made since that time have afforded the material for a much more comprehensive and thorough treatment of the subject, and the results of a careful study of thirty-nine slides are herewith given. The Aphis-eating habit of the Coccinellidæ is a fact of such easy observation, and is so thoroughly well known, that I have not thought it worth while to investigate especially the food of beetles of this family taken among plant-lice.

The collections from which the present notes are derived, are from a variety of miscellaneous situations, and also from a cornfield mentioned in the notes on the food of the preceding family, in which chinch-bugs were superabundant, the purpose of the latter collection being to determine the food relations of the Coccinellidæ to those insects. It so happened that the same field was infested by the corn Aphis in great numbers, and the specimens obtained therein consequently illustrate to some extent the food of the lady-bugs in the presence of plant-lice. It was in this last situation only that larvæ were collected, and the facts here given consequently relate almost wholly to the adult beetles.

Genus Hippodamia.

Eleven specimens of *H. maculata*, taken in Northern, Central, and Southern Illinois at various seasons of the year, from April to

September, give an average of forty-six per cent. of animal food, all insects excepting a few mites eaten by three of the beetles, and amounting to only one per cent. of the food. The insect ratio, as far as recognized, with the exception of a single Podura, consisted wholly of plant-lice, which amounted to thirty-five per cent., while the fifty-four per cent. of vegetable food contained only pollen of plants and spores of lichens and fungi, the pollen and spores occurring in about equal quantities. The former was chiefly from flowers of grass and composite plants, about seven per cent. of the first and fifteen per cent. of the second. One per cent. of the pollen of Polygonum, and a trace of the pollen of pine, both eaten by a single beetle, are the only other items under this head. Lichen spores, including Physcia, were reckoned at two per cent., and those of fungi at twenty-five per cent. At least two-thirds of the latter, eaten by nearly half the beetles, consisted of spores of Helminthosporium.

Three specimens of this species, taken in the corn-field at Jacksonville, had eaten much smaller ratios of animal food, which amounted to only thirteen per cent., all insects. Traces of plant-lice were recognized, but no structures of chinch-bugs occurred. All but five per cent. of the vegetable food was derived from spores of fungi, very largely Cladosporium. Helminthosporium amounted to nine per cent. Macrosporium and Septoria were also found. Three per cent. of the spores of Physcia and other lichens, and two per cent. of the pollen of rag-weed and other Compositæ, complete the record.

Four examples of *H. convergens*, all taken at Normal in August and September, had eaten about the same amount of animal food as the preceding species (forty per cent.), but differed in the distribution of it by the fact that one of the specimens had eaten a myriapod (Geophilus), and that a caterpillar had been taken by another. Insects proper amounted to but twenty-five per cent., over half plant-lice. The vegetable food of this species stands at fifty-six per cent., as compared with fifty-four of the preceding, and the ratios under this head are very similar to those just given for the other species. Pollen of Compositæ (dandelion) makes thirteen per cent. that of grass makes five per cent., spores of lichens two, and those of fungi thirty-three per cent. As in *H. maculata*, Helminthosporium was by far the most important

fungus element. The other genera recognized were Septoria, Ustilago, Macrosporium, Coleosporium, Peronospora, Menispora, and some spores of Sphæronemei and Myxogastres.

Five adults, taken at Jacksonville, were found to have made about one-third of their food of insects, equally divided between plant-lice and chinch-bugs, each eaten by one of the beetles. The vegetation consisted, as usual, of pollen of Compositæ (eleven per cent.), spores of lichens (two per cent.), and of fungi (seventy-one per cent.). The list of the last includes Septoria, Ustilago, Helminthosporium, Macrosporium, Cladosporium, and Peronospora.

Two larvæ of this species, taken at the same place and time, differed but little in food, to my surprise, from the adults just mentioned. Chinch-bugs, plant-lice, and caterpillars, in about equal ratios, with traces of unrecognizable insects, amount to twenty-three per cent. Pollen of Compositæ stands at five per cent., lichen spores at seven, and spores of fungi at sixty-five, including the same genera as those just mentioned, except Peronospora and Septoria.

H. glacialis was represented by four specimens, taken in the corn-field. The differences between their food and that of *H. convergens* were purely trivial. Insects amount to thirty per cent., all chinch-bugs and plant-lice, twelve per cent. of the former and eighteen of the latter. The seventy per cent. of vegetable food is divided about as before, between pollen of Compositæ, seven per cent., and spores of fungi fifty-one per cent. Lichen spores were taken more freely, however, and were estimated at twelve per cent., eaten by all the beetles. The fungi were mostly Cladosporium (forty-three per cent.), but Septoria, Uredo, Helminthosporium and Peronospora likewise occur.

Genus Coccinella.

Six specimens of this genus were studied, three of *C. 9-notata*, and three of *C. 5-notata*. All were from Central Illinois except one, which was from Jacksonville. Excluding the last, the ratio of animal food eaten by these specimens was not far from two-thirds of the total, all plant-lice. Only a trace of pollen of Compositæ was noticed in one of the insects. Fungus spores amounted to thirty-two per cent. (about half Helminthosporium and Ustilago),

and lichen spores to four per cent. The Jacksonville specimen had eaten only fungi.

Genus Cycloneda.

In the corn-field with the chinch-bugs, three specimens of *C. sanguinea* were collected, which had eaten plant-lice, pollen of Compositæ, lichen spores and spores of fungi. The first made about one-third of their food, the pollen grains were estimated at nearly half, and lichen spores at three per cent. The eighteen per cent. of fungi were of the usual character.

The Family as a Unit.

A summary and comparison of the food of these two groups, taken singly without reference to their genera, develops some interesting and unexpected facts. Although the corn-field in which the second collection was made was teeming with insects of the kinds especially tempting to the Coccinellidæ, and although these beetles themselves were there in truly surprising numbers, it is not easy to believe, considering the tables upon which this discussion is based, that the Coccinellidæ were attracted to the field by the abundance of insects available for their food. The beetles of the first group are seen to have eaten nearly twice as many insects as those from the field of corn, while the fungi eaten were as thirty-six to fifty-six respectively. Only eighteen specimens were dissected, out of the large number collected in the corn-field, but the contents of their stomachs were of so uniform a character that there was every reason to suppose that they illustrated correctly the food of the family at that time and place. It would therefore seem possible that these beetles were attracted rather by the stores of fungi in the field, than by the chinch-bugs and Aphides. The condition of the leaves and stalks of the corn, drained and deadened by insect depredations, was such as to afford an excellent nidus for the development of those fungi which spring up every where spontaneously upon dead and decaying vegetation, and these were in fact extremely abundant. An alternative explanation is perhaps more probable. The condition of the field gave abundant evidence that the plant-lice had been very much more numerous some time before; and it is possible that, as a consequence of this decrease of food, and the increase of

the Coccinellidæ themselves, the latter had reached an excessive number, for which the supply of plant-lice was really insufficient, and that for this reason they had resorted to fungi.

The chinch-bugs taken by the specimens of the second group amounted to only eight per cent. of their entire food, and plant-lice to fourteen per cent., — less than half those taken by the other specimens, which stand at thirty-six per cent. The pollen eaten by each group was thirteen per cent.,—the same in both. If we combine the two collections, and treat the thirty-nine specimens of both as a whole, we find that insect food is about a third of the entire amount, and that the other animal elements are only trivial. The function of the beetles of this family of limiting the multiplication of plant-lice is expressed by the fact that these insects compose a fourth of the food of this entire collection. The pollen of grasses and Compositæ make fourteen per cent., the spores of lichens four per cent., and those of fungi nearly half the whole (forty-five per cent.). The list of genera, as far as recognized, and the relative importance of these, may be found by reference to the tables at the end of this paper.

Sufficiency of Data.

The food of the Coccinellidæ seems to be, on the whole, remarkably simple and uniform, consisting almost wholly of spores of the lower cryptogams, pollen grains, and plant-lice, and varying but little from one genus to another. This similarity is likewise reflected in the mouth parts, which agree as closely in form and structure as do the ratios of the food. I have consequently little doubt that the data derived from the thirty-nine specimens here discussed, will be found sufficient for a correct general idea of the food of the family under ordinary circumstances.

With respect to the Carabidæ, we have other proof. In the preliminary paper in Bulletin 3 already referred to, based on an examination of only twenty-eight specimens belonging to seventeen species, the conclusion was announced that about one-half of the food of this family consisted of vegetation, and one-third of insects; and the vegetation was thought to be about equally divided between cryptogams, grasses and exogens. If these figures or those of the present paper were far wrong, the probabilities would be very slight indeed that the two estimates would agree,

especially as no comparison whatever was made of the two sets of data until the tables were completed in their present form. When, therefore, we find that the one hundred and seventy-five specimens of the present paper, belonging to thirty-eight species, were estimated to have taken fifty-seven per cent. of animal food and thirty-six of insects, and that the ratios of cryptogams, graminaceous plants and exogens are respectively five, eleven, and five, we must conclude that these figures are a fair average of the ordinary food of the family.

Relations to Birds.

The foregoing pages have set forth the relations of the Carabidæ and the Coccinellidæ to the species upon which they feed, and a few general statements will now be proper concerning the animals which prey upon them in turn. Predaceous ground-beetles are peculiarly exposed to birds which commonly seek their food upon the ground, and we need not be surprised to find that they enter largely into the food of such species as the thrushes and the bluebird. Carabidæ were found to furnish about five or six per cent. of the food of four hundred and twenty-three specimens of these birds, as stated in a paper on that subject in the third Bulletin of this series, but Coccinellidæ did not occur at all. Indeed, in the food of more than four hundred other birds, of various families, Coccinellidæ were found only in Regulus, where a single species was reckoned at one per cent. of the food.

The great differences in the food of the Carabidæ, disclosed by this paper, give considerable importance to the question of the kinds of these beetles most freely eaten by birds, and the following list of species and genera recognized in the food of the collection of thrushes and bluebirds above mentioned is given as an answer.

It will be seen that there is a very wide difference between the number of Carabidæ proper taken by these birds, and the number of Harpalidæ, representatives of the former group occurring in only six specimens, and of the latter in one hundred and sixteen. On the other hand, fifty-nine of the birds had taken Harpalids which may be fairly classed with the second group established in this paper, and fifty-seven had taken those belonging to the third group, or phytophagous Carabidæ. The genera most preyed

upon are Harpalus, taken by twenty-eight of the birds, Anisodactylus by eighteen, Agonoderus by fourteen, Cratacanthus by thirteen, Pterostichus by twelve, and Evarthrus by eleven; numbers which represent fairly well the relative abundance of individuals, taking the entire season through. We note, however, a remarkable deficiency of the highly colored genera,--such as Galerita, Brachynus, Lebia, Platynus, Chlænius, etc., which are either absent, or found but rarely in these birds' food. Evidently these more showy beetles are protected by some more effective means than obscurity of color. In the following list, the figure preceding the name of each species of bird denotes the number of specimens in which the insect mentioned was found:

LIST OF GENERA AND SPECIES OF CICINDELIDÆ AND CARABIDÆ EATEN BY 423 OF THE THRUSHES AMD THE BLUEBIRD.

1. Cicindela lecontei: 1 Mimus carolinensis.
2. Carabus palustris: 1 Sialia sialis.
3. Scarites, sp.: 1 Harporhyncus rufus.
4. Dischyrius globulosus: 1 Turdus pallasi.
5. Aspidoglossa subangulata: 2 Mimus carolinensis.
6. Clivina bipustulata: 1 Harporhyncus rufus.
7. Platynus, sp.: 1 Mimus carolinensis, 1 Harporhyncus rufus, 1 Sialia sialis.
8. Evarthrus, sp.: 1 Turdus mustelinus, 1 T. migratorius, 2 Mimus carolinensis, 5 Sialia sialis.
9. E. colossus: 1 Turdus pallasi, 1 Harporhyncus rufus.
10. Pterostichus sp.: 1 Turdus mustelinus, 1 T. pallasi, 1 T. migratorius, 1 Harporhyncus rufus, 5 Sialia sialis.
11. P. lucublandus: 1 Turdus mustelinus, 1 Sialia sialis.
12. P. sayi: 1 Mimus carolinensis.
13. Amara, sp.: 1 Turdus pallasi, 1 T. swainsoni, 1 T. migratorius, 2 Sialia sialis.
14. Brachylobus lithophilus: 3 Turdus migratorius.
15. Chlænius, sp.: 1 Turdus migratorius, 1 Sialia sialis.
16. C. tomentosus: 1 Sialia sialis.
17. Lachnocrepis parallelus: 1 Turdus migratorius.
18. Geopinus incrassatus: 1 Turdus migratorius.
19. Cratacanthus dubius: 1 Turdus mustelinus, 3 T. migratorius, 2 Mimus carolinensis, 2 Harporhyncus rufus, 5 Sialia sialis.

20. Agonoderus, sp.: 2 Turdus migratorius, 1 Mimus carolinensis, 1 Harporhyncus rufus, 1 Sialia sialis.
21. A. pallipes: 2 Turdus migratorius, 1 Mimus carolinensis, 1 Harporhyncus rufus, 2 Sialia sialis.
22. A. partiarius: 1 Turdus migratorius.
23. Anisodactylus, sp.: 1 Turdus mustelinus, 1 T. swainsoni, 2 T. migratorius, 2 Harporhyncus rufus, 6 Sialia sialis.
24. A. rusticus: 1 Sialia sialis.
25. A. discoideus: 1 Turdus pallasi.
26. A. baltimorensis: 2 Turdus migratorius, 1 Mimus carolinensis, 1 Sialia sialis.
27. Xestonotus lugubris: 1 Turdus mustelinus, 1 Sialia sialis.
28. Harpalus, sp.: 1 Turdus mustelinus, 7 T. migratorius, 4 Mimus carolinensis, 8 Harporhyncus rufus, 6 Sialia sialis.
29. H. herbivagus: 1 Turdus migratorius.
30. H. pennsylvanicus: 1 Mimus carolinensis.
31. Stenolophus, sp.: 2 Turdus pallasi.

In the following tables, the elements of the food, arranged in systematic order, are placed at the left of each page, while a vertical column of the table is assigned to each genus of beetle. The upper figure of each couple indicates the number of specimens in which the given element was found, while the lower figures (decimal) show the ratio of the element to the entire food of of all the examples of the genus. The dagger has been used to indicate a trace too small to figure in the percentages, usually less than one-half per cent., and an asterisk denotes that the element against which it is placed was present in the food, but that the ratio was not estimated.

CARABIDÆ.—MISCELLANEOUS COLLECTIONS.

	Calosoma.	Scarites.	Brachynus.	Galerita.	Lebia.	Calathus.	Platynus.	Evarthrus.	Pterostichus.	Amara.	Dicælus.	Chlænius.	Cratacanthus.	Agonoderus.	Anisodactylus.	Amphasia.	Bradycellus.	Harpalus.	Patrobus.	Summary.
No. of Specimens	1	2	1	4	3	3	2	5	7	4	2	6	1	4	19	4	1	12	2	83
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.																			
ANIMAL FOOD	1 1.00	2 1.00	1 1.00	4 .88	2 .44	2 .65	1 .17	5 .90	6 .73	1 .22	2 1.00	5 .75	...	1 .01	3 .24	1 .03	1 1.00	4 .07	1 .33	43 .42
I. INSECTA		1 .50		4 .88	1 .11	2 .65	1 .17	5 .90	4 .43			5 .67			2 .03	1 .03	1 1.00	2 .03	1 .33	30 .26
Larvæ						1 .32		1 .10				1 .08								3 .02
1. *Hymenoptera*									1 .13									1 .01		2 .01
Formicidæ																		1 .01		1 †
2. *Lepidoptera* (larvæ)				3 .63		1 .33		1 .20				1 .17						1 .02	1 .30	8 .08
3. *Diptera*																		1 †		1 †
4. *Coleoptera*								2 .39												2 .02
Larvæ								1 .19												1 .01
Scarabæidæ								1 .20												1 .01
5. *Hemiptera* (Aphides)							1 .17												1 .03	2 .01
II. ARACHNIDA (Mites)									1 .01	1 .22				1 .01				2 .01		5 .01
III. VERMES (Lumbricus)												1 .08								1 .01
VEGETABLE FOOD				2 .12	3 .56	2 .35	2 .83	1 .10	4 .27	4 .78		2 .25	1 1.00	4 .99	15 .76	4 .97		12 .93	2 .67	58 .58
Seeds														2 .48	3 .16	1 .22		1 .08	1 .50	8 .10
1. *Exogens*							1 .50		2 .14	1 .25		1 .08						3 .17		8 .07
Seeds									1 †											1 †
Compositæ (Pollen)																		3 .17		3 .03
Ambrosia																		2 .17		2 .03
2. *Endogens*				1 .10	1 .11	2 .35	1 .30	1 .10		1 .28				1 .25	7 .34			4 .23	1 .10	20 .17
Gramineæ				1 .10	1 .11	2 .35	1 .30			1 .28				1 .25	7 .34			4 .23	1 .10	18 .17
Seeds							1 .30			1 *					1 .05			1 †		4 .02
Pollen					1 .11	2 .35														4 .02
Phleum (seeds)														1 .25	4 .21					5 .06
3. *Hepaticæ*															2 .01					2 †
4. *Algæ*								1 †				1 †								2 †
Protococcus												1 †								1 †
5. *Fungi*				1 †	3 .45		1 .03	1 †	3 .07	1 .21		1 .14	1 1.00	2 .11	3 .04			5 .13	1 .07	23 .09
Coprinus												1 .14								1 .01
Phoma					2 .45															1 .02
Coleosporium															1 †					1 †
Dematiei												1 †								1 †
Helminthosporium					2 †				1 †				1 1.00					2 †		6 .01
Cladosporium														1 .01	1 .01					2 †
Peronospora										1 .19					1 †			1 .03		3 .01
Ramularia														1 .10						1 .01

CARABIDÆ AND CANKER-WORMS.

	Calosoma.	Pasimachus.	Scarites.	Galerita.	Calathus.	Platynus.	Evarthrus.	Pterostichus.	Amara.	Dicælus.	Chlænius.	Anisodactylus.	Amphasia.	Harpalus.	Summary.
No. of Specimens	10	2	4	13	3	1	2	3	1	1	16	10	1	3	70
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.														
ANIMAL FOOD	10 1.00	2 1.00	4 1.00	13 .94	3 .68	1 1.00	2 1.00	3 .80	..	1 1.00	16 .92	1 .09	1 .25	2 .35	59 .77
I. MOLLUSCA	....	....	....	....	....	....	....	....	....	1 1.00	....	....	....	....	1 .02
II. INSECTA	5 .50	....	2 .50	13 .85	3 .68	....	2 1.00	1 .13	....	....	12 .64	1 .09	1 .25	2 .35	42 .50
Larvæ	....	....	....	2 .11	....	....	....	....	....	....	1 .06	....	....	....	3 .04
1. *Hymenoptera* (ants)	....	....	....	....	....	....	1 .05	....	....	....	....	....	....	....	1 †
2. *Lepidoptera* (larvæ)	....	....	....	8 .56	1 .33	....	2 .90	1 .11	....	....	8 .41	....	....	1 .33	21 .26
Anisopteryx vernata	....	....	....	7 .52	1 .33	....	2 .90	....	....	....	5 .26	....	....	1 .33	16 .21
Noctuidæ	....	....	....	1 .01	....	....	....	....	....	....	2 .12	....	....	....	3 .03
3. *Diptera*	....	....	....	3 .07	1 .02	....	1 .05	....	....	....	1 .01	1 .09	....	....	7 .03
Culicidæ	....	....	....	....	....	....	1 .05	....	....	....	....	....	....	....	1 †
4. *Coleoptera*	....	....	....	....	....	....	....	....	....	....	1 .06	....	....	....	1 .01
Telephoridæ	....	....	....	....	....	....	....	....	....	....	1 .06	....	....	....	1 .01
III. ARACHNIDA	....	....	....	3 .05	....	....	....	....	....	....	1 .02	....	....	....	4 .01
Spiders	....	....	....	1 .05	....	....	....	....	....	....	....	....	....	....	1 .01
Mites	....	....	....	2 †	....	....	....	....	....	....	1 .02	....	....	....	3 †
IV. MYRIAPODA (Geophilus)	....	....	....	....	....	....	....	....	....	....	1 .01	....	....	....	1 †
V. VERMES (Lumbricus)	....	....	..	....	....	....	....	....	....	....	4 .25	....	....	....	4 .06
VEGETABLE FOOD	....	....	....	2 .06	1 .32	...	....	1 .20	1 1.00	....	5 .08	10 .91	1 .75	2 .65	23 .23
Seeds	....	....	....	....	....	....	....	....	....	....	....	3 .20	....	1 .32	5 .04
1. *Exogens*	....	....	....	2 .06	....	....	....	....	....	....	....	1 .10	....	1 .17	4 .03
2. *Endogens*	....	....	....	....	....	....	....	1 .20	....	....	1 .01	5 .50	....	1 †	10 .08
Gramineæ	....	....	....	....	....	....	....	....	....	....	....	4 .40	....	....	4 .06
Seeds	....	....	....	....	....	....	....	....	....	....	....	4 .30	....	....	4 .04
3. *Fungi*	....	....	....	....	....	....	....	....	1 †	....	2 .04	....	....	1 .16	4 .02
Peronospora	..	....	....	....	....	....	....	....	....	....	....	....	....	1 .16	1 .01
Ascomycetes	....	....	....	....	....	....	....	....	....	....	1 .02	....	....	....	1 †

CARABIDÆ, AND CABBAGE WORMS AND CHINCH-BUGS.

	Pterostichus.	Amara.	Chlænius.	Agonoderus.	Anisodactylus.	Harpalus.	Summary.	Agonoderus.
Number of Specimens Examined..	3	1	1	1	2	4	12	10
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.							
ANIMAL FOOD	3 .67	1 .50	1 1.00	......	1 .50	1 .10	7 .41	8 .51
I. INSECTA	2 .33	......	1 1.00	......	......	1 .10	4 .20	3 .36
Larvæ	......	......	......	......	......	......	......	1 .02
1. *Hymenoptera*	......	......	......	......	......	......	......	1 .05
Lasius flavus	......	......	......	......	......	......	......	1 .05
2. *Lepidoptera*	1 .33	......	1 .60	......	......	......	2 .13	......
Caterpillars	......	......	1 .60	......	......	......	1 .05	......
Agrotis annexa	1 .33	......	......	......	......	......	1 .08	......
3. *Diptera*	......	......	......	......	......	1 .10	1 .03	......
4. *Coleoptera* (larvæ)	......	......	1 .30	......	......	......	1 .03	......
5. *Hemiptera*	......	......	......	......	......	......	......	5 .29
Aphides	......	......	......	......	......	......	......	2 .08
Chinch-bugs	......	......	......	......	......	......	......	4 .21
VEGETABLE FOOD	1 .33	1 .50	1 †	1 1.00	1 .50	4 .90	9 .59	7 .49
Seeds	......	1 *	......	......	1 *	4 .90	6 .30	......
1. *Exogens*	......	......	......	......	......	......	......	2 .13
2. *Endogens*	1 .33	1 *	1 †	......	......	1 †	4 .08	2 .11
Grass	1 .33	1 *	......	......	......	1 †	3 .08	......
3. *Fungi*	......	......	......	......	......	......	......	2 .02
Helminthosporium	......	......	......	......	......	......	......	1 .01
Peronospora	......	......	......	......	......	......	......	1 .01

CARABIDÆ. GENERAL TABLE.

	Calosoma.	Pasimachus.	Scarites.	Brachynus.	Galerita.	Loxopeza.	Calathus.	Platynus.	Evarthrus.	Pterostichus.	Amara.	Dicælus.	Chlænius.	Cratacanthus.	Agonoderus.	Anisodactylus.	Amphasia.	Bradycellus.	Harpalus.	Patrobus.	Summary.
No. of Specimens	11	2	6	1	17	3	6	3	7	13	6	3	23	1	15	31	5	1	19	2	175
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.																				
ANIMAL FOOD	11 1.00	2 1.00	6 1.00	1 1.00	17 .93	2 .44	5 .67	2 .45	7 .93	12 .73	2 .23	3 1.00	22 .88		9 .34	5 .21	2 .07	1 1.00	7 .12	1 .33	117 .57
I. MOLLUSCA (slugs)												1 .33									1 .01
II. INSECTA	5 .45		3 .50		17 .86	1 .11	5 .67	1 .12	7 .93	7 .34			18 .67		6 .24	3 .05	2 .07	1 1.00	5 .09	1 .33	82 .36
Larvæ					2 .09		1 .16		1 .07				2 .06		1 .02						7 .03
1. *Hymenoptera*									1 .02	1 .07					1 .03				1 .01		4 .01
Formicidæ															1 .03				1 .01		3 †
Lasius flavus															1 .03						1 †
2. *Lepidoptera*					11 .58		2 .33		3 .40	2 .10			10 .36						2 .06	1 .30	31 .15
Larvæ					5 .18		1 .17		1 .14	1 .03			3 .05						1 .01	1 .30	13 .04
Anisopteryx vernata					7 .39		1 .16		2 .26				4 .18						1 .05		16 .08
Noctuidæ (larvæ)					1 .01								2 .09								4 .02
Agrotis annexa										1 .07											1 .01
3. *Diptera*					3 .05		1 .01		1 .01				1 †			1 .03			1 .02		9 .01
Culicidæ									1 .01												1 †
4. *Coleoptera*									2 .28				2 .06								4 .02
Larvæ									1 .14				1 .01								2 .01
Scarabæidæ									1 .14												1 †
Telephoridæ													1 .05								1 .01
5. *Hemiptera*								1 .12							5 .19					1 .03	7 .02
Aphides								1 .12							2 .05					1 .03	4 .01
Chinch-bugs															4 .14						4 .01
III. ARACHNIDA					3 .04					1 .01	1 .15		1 .01		1 †				2 .01		9 .01
Spiders					1 .04																1 †
Mites					2 †					1 .01	1 .15		1 .01		1 †				2 .01		8 .01
IV. MYRIAPODA (Geophilus)													1 .01								1 †
V. VERMES (Lumbricus)													5 .19								5 .02
VEGETABLE FOOD					4 .07	3 .56	3 .33	2 .55	1 .07	6 .27	5 .77		8 .12	1 1.00	12 .56	26 .79	5 .93		18 .88	2 .67	97 .43
Seeds											2 *				2 .13	7 .16	1 .18		6 .29	1 .50	19 .08
1. *Exogens*					2 .04			1 .33		2 .08	1 .16		1 .02		2 .09	1 .03			4 .14		14 .05
Seeds										1 *											1 *

CARABIDÆ. GENERAL TABLE—Concluded.

	Calosoma.	Pasimachus.	Scarites.	Brachynus.	Galerita.	Loxopeza.	Calathus.	Platynus.	Evarthrus.	Pterostichus.	Amara.	Dicælus.	Chlænius.	Cratacanthus.	Agonoderus.	Anisodactylus.	Amphasia.	Bradycellus.	Harpalus.	Patrobus.	Summary.
No. of Specimens	11	2	6	1	17	3	6	3	7	13	6	3	23	1	15	31	5	1	19	2	175
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.																				
Compositæ (pollen)																			3 11		3 .01
Ambrosia																			2 .11		2 .01
2. *Endogens*					1 .02	1 .11	2 .17	1 .20	1 .07	2 .12	1 *		4 .01		3 .14	12 .37			6 .14	1 .10	36 .13
Gramineæ					1 .02	1 .11	2 .17	1 .20		1 .08	1 *				2 .10	36 .34			5 .14	1 .10	25 .11
Seeds								1 .20			1 *					5 .13			1 †		8 .03
Pollen						1 .11	2 .17														4 .01
Phleum (seeds)															1 .07	4 .13					5 .03
3. *Hepaticæ*																2 †					2 †
4. *Algæ*									1 †				1 †								2 †
Protococcus													1 †								1 †
5. *Fungi*					1 †	3 .45		1 .02	1 †	3 .04	1 .14		3 .06	1 1.00	4 .04	3 .03			6 .11	1 .07	29 .05
Coprinus													1 .04								1 †
Phoma						2 .45															1 .01
Coleosporium																1 †					1 †
Dematiei													1 †								1 †
Helminthosporium						2 †								1 1.00	1 .01				2 †		6 .01
Cladosporium															1 †	1 .01					2 †
Peronospora											1 .12				1 †	1 †			2 .05		5 .01
Ascomycetes										1 †			1 .01								2 †
Ramularia															1 .03						1 †

COCCINELLIDÆ.

	Miscellaneous.				Chinch-bugs.				General.				
	Hippodamia.	Coccinella.	Brachyacantha.	Summary.	Hippodamia.	Coccinella.	Cycloneda.	Summary.	Hippodamia.	Coccinella.	Cycloneda.	Brachyacantha.	Summary.
Number of Specimens	15	5	1	21	14	1	3	18	29	6	3	1	39
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.												
ANIMAL FOOD	12 .44	5 .64	....	17 .47	12 .25	...	2 .32	14 .25	24 .35	5 .53	2 .32	....	31 .37
I. INSECTA	11 .39	5 .64	....	16 .43	12 .25	....	2 .32	14 .25	23 .32	5 .53	2 .32	....	30 .35
1. *Lepidoptera*	1 †	....	....	1 †	1 .01	....	....	1 .01	2 .01	....	....	....	2 .01
Larvæ	....	....	....	....	1 .01	....	....	1 .01	1 .01	....	....	....	1 .01
2. *Hemiptera*	8 .29	5 .64	....	13 .36	7 .21	....	2 .32	9 .22	15 .25	5 .53	2 .32	....	22 .29
Aphides	8 .29	5 .64	....	13 .36	4 .11	....	2 .32	6 .14	12 .20	5 .53	2 .32	....	19 .26
Siphonophora granariæ	....	....	....	....	2 .05	....	1 .24	3 .08	2 .02	....	1 .24	....	3 .03
Chinch-bugs	....	....	....	....	4 .10	...	....	4 .08	4 .05	....	....	....	4 .03
3. *Neuroptera* (Podura)	1 .01	....	....	1 .01	....	....	....	....	1 †	....	....	....	1 †
II. ARACHNIDA (Mites)	4 .01	....	....	4 .01	2 †	....	....	2 †	6 .01	....	....	....	6 †
III. MYRIAPODA (Geophilus)	1 .04	....	....	1 .03	....	....	....	....	1 .02	....	....	....	1 .02
VEGETABLE FOOD	13 .56	2 .86	1 1.00	16 .53	14 .75	1 1.00	3 .68	18 .75	27 .65	3 .47	3 .68	1 1.00	34 .63
Pollen	1 .03	1 †	....	2 .02	....	....	....	....	1 .01	1 †	....	....	2 .01
1. *Exogens* (Pollen)	7 .13	....	....	7 .09	13 .07	....	3 .47	16 .13	20 .10	....	3 .47	....	23 .11
Compositæ	6 .13	....	....	6 .09	13 .07	....	3 .47	16 .13	19 .10	....	3 .47	....	22 .11
Taraxacum	1 .07	....	....	1 .05	....	....	....	....	1 .04	....	....	....	1 .03
Ambrosia	....	....	....	....	2 *	....	....	2 †	2 *	....	....	....	2 *
Polygonum	1 †	....	...	1 †	1 *	....	....	1 †	2 †	....	....	....	2 *
Coniferæ	1 †	....	....	1 †	...	....	....	....	1 †	....	....	....	1 †
2. *Endogens*	1 .05	....	....	1 .04	....	....	....	....	1 .03	....	....	....	1 .02
Gramineæ	1 .05	....	....	1 .04	....	....	....	....	1 .03	....	....	....	1 .02
Pollen	1 .05	....	....	1 .04	....	....	....	....	1 .03	....	....	....	1 .02
3. *Lichenes*	4 .02	1 .04	....	5 .02	11 .06	....	2 .03	13 .05	15 .04	1 .03	2 .03	....	18 .04
Physcia	1 .01	....	....	1 †	6 *	....	1 †	7 †	7 .01	....	1 †	....	8 .01
4. *Fungi*	11 .33	2 .32	1 1.00	14 .36	14 .61	1 1.00	2 .18	17 .56	25 .46	3 .44	2 .18	1 1.00	31 .45
Myxogastres	1 *	....	....	1 †	....	....	....	....	1 †	....	...	....	1 *
Sphæronemei	1 *	....	....	1 .01	....	....	....	....	1 *	....	....	....	1 *
Septoria	1 *	....	....	1 .01	7 *	....	1 *	8 *	8 *	....	1 *	....	9 *
Ustilago	1 *	2 .08	....	3 .02	2 *	....	....	2 *	3 *	2 .07	....	....	5 *
Uredo	....	....	....	....	1 *	....	....	1 *	1 †	....	....	....	1 *
Helminthosporium	6 *	1 .10	1 1.00	8 .17	11 *	....	1 *	12 *	17 *	1 .08	1 *	1 1.00	20 *
Macrosporium	3 *	....	....	3 .04	7 *	....	1 *	8 *	10 *	....	....	....	11 *
Cladosporium	3 *	....	....	3 .02	13 *	....	2 *	15 *	16 *	....	....	....	18 *
Peronospora	3 *	....	....	3 .01	7 *	....	....	7 *	10 *	....	....	....	10 *
Menispora	1 *	....	....	1 †	....	....	....	....	1 *	....	....	....	1 *

THE FOOD OF THE SMALLER FRESH-WATER FISHES.

BY S. A. FORBES.

In a paper on the food of fishes, published in 1880,* I characterized the food of all the Illinois Acanthopteri, with the exception of the Aphredoderidæ; and in the present article, which is to be regarded as a continuation of that just mentioned, I propose to summarize my observations on all the smaller fishes occurring in the waters of the State, with the exception of the darters (Etheostomatinæ), which were treated in the preceding paper.

The purposes and methods of the investigation upon which the following discussion is based, are so similar to those already described, that they will not need any especial present explanation. The data for it have been obtained by a minute and careful study of the contents of the alimentary canals of 319 specimens, belonging to twenty-five species, representing twenty-two genera and seven families, namely: Aphredoderidæ, Cottidæ, Gasterosteidæ, Atherinidæ, Cyprinodontidæ, Umbridæ, and Cyprinidæ.

An additional feature is the description of the structures subsidiary to alimentation, given, in this paper, for each genus, in order to furnish a basis for a more exact discussion of the relations of structure to food-habits than I attempted formerly. Under this head I have included the length and complication of the alimentary canal, the character of the pharyngeal structures, the number and development of the gill-rakers, and the presence of any peculiar prehensile apparatus about the mouth.

First giving for each species a brief account of its numbers and distribution throughout the State, I shall add for each genus a description of these alimentary structures, following this by a detailed statement of the observations made upon its food, and closing with a summary of such observations, and a discussion of the correlations of structure to food characters, given sometimes

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*Bulletin No. 3, Ill. State Lab. Nat. Hist., pp. 18–65.

under the genus and sometimes under the special group to which the genus is assigned.

FAMILY APHREDODERIDÆ.

This family is represented by a single peculiar species (*Aphredoderus sayanus*), resembling the sun-fishes in most of its characters, but remarkably distinguished by the fact that the vent, although occupying the normal position in the young, opens in the adult far forward under the head, moving gradually to the front with increasing size. This fish is not over three inches in length. It occurs in rivers and smaller streams, as well as in lakes and ponds throughout the State. We have collected it from the Illinois River and various tributaries, as well as from the lakes connected with that stream, and from ponds and creeks throughout Southern Illinois. It has also been taken in the Calumet River near Chicago, and from lakes in that vicinity, but is not known to occur in Lake Michigan. It is said to be nocturnal in its habits, by Dr. C. C. Abbott, who kept specimens in an aquarium for some time.* The same author reports that in confinement it feeds voraciously upon small fishes, especially immature Cyprinidæ; and for this reason he bestowed upon it the name of *pirate perch*, by which it has become generally known among ichthyologists. The observations presently to be detailed will show, however, that his specimens were doubtless forced to feed so largely upon fishes for want of food more natural to them, since in their native haunts fishes make but a small percentage of their ordinary food.

The intestine of this species is short and simple, less than the length of the head and body without the tail, and distinguished only by the character previously mentioned. The gill apparatus is ineffective, the rakers being very short, thick, blunt, and few, and covered with short spinules. The pharyngeal jaws consist of small plates, covered with short, sharp spinulose teeth, similar to those of the sun-fishes. The mouth is large, but not remarkably protractile.

The specimens dissected number nineteen, representing seven different dates and localities, throughout Central and Southern Illinois. Some were taken from small temporary ponds left by

*Proc. Phil. Acad. Nat. Sci., 1861, p. 95.

the retreating overflow of streams, others from permanent lakes, and still others from creeks and rivers. The food from the different localities varies but little, on the whole, and it is scarcely worth while to discuss the separate collections. That of these nineteen specimens was almost purely animal, traces of a minute flowering plant (Wolffia), and small quantities of filamentous Algæ only being taken by two of the specimens. Fishes were eaten by but two, and were reckoned at two per cent. of the food of the whole. One of these found was recognizable as a Cyprinoid, but the other could not be determined. Insects amounted to more than ninety per cent., all of them aquatic, with the exception of a few gnats (Culicidæ) taken by eight of the fishes. Nearly half of the food consisted of larvæ of Chironomus and Corethra. Aquatic coleopterous larvæ were reckoned at eleven per cent., and specimens of Corixa, taken by three of the fishes, at two. A single fish had also eaten Galgulus. A fourth of the food consisted of neuropterous larvæ (Ephemeridæ and Libellulidæ). Crustaceans, though captured by more than half the fishes, made but four per cent. of the food. As far as recognized, this element consisted chiefly of the amphipod, *Allorchestes dentata*, and the common isopod, Asellus. A few specimens of Cyprididæ were noticed in two of the fishes, and Cyclops and other Copepoda were taken by five. One fish had eaten a Lumbriculus, a species closely allied to the common earthworm.

A careful comparison was made of the food of specimens of various ages — those, consequently, in which the situation of the vent was widely different — but no differences of food whatever were distinguishable. It is highly probable, consequently, that the explanation of this peculiar character must be sought elsewhere than in the food. With respect to the other relations of food to structure, we have at present only to note the coïncidence of fishes and aquatic insects as the principal elements of the food with the large mouth and inferior development of the gill and pharyngeal apparatus, and short and simple intestine.

FAMILY COTTIDÆ.

This curious family, chiefly marine, is represented in the State by several species from Lake Michigan, mostly from its deeper waters, and by a single one recently discovered in our streams.

Potamocottus meridionalis, Gill. Goblin, Blob.

Although this fish has not hitherto been recorded from the State, we have found it abundant in small streams in Southern Illinois, and a single specimen has been sent us from McHenry County, near our northern limits. The first of these situations is in a limestone region, where small caves are not infrequent; but the second is in an area deeply covered by drift, with rock nowhere exposed.

The general appearance of this fish is not unlike that of a catfish, the head being broad and flat, the mouth very large, and the skin smooth. The gill-rakers are few, short and thick, and of insignificant character; the pharyngeals are similar to those of Aphredoderus, but form thicker and larger plates; the intestine is short and simple, its entire length being less than that of the head and body.

Six specimens of this species, taken in Southern Illinois, had eaten only animal food, about one-fourth of which consisted of fishes, one of which was furnished with ctenoid scales. Undetermined aquatic larvæ (thirty-six per cent.) and other insects, were estimated at forty-four per cent. of the food. Crustacea, all belonging to the genus Asellus, eaten by two of the fishes, composed the remaining twenty-nine per cent. The general resemblance of the food of this species to that of Aphredoderus seemingly corresponds to the similar character of their alimentary structures.

FAMILY GASTEROSTEIDÆ.

Of the interesting little stickle-backs, two species were studied, only one of which is common in the State.

Eucalia inconstans, Kirt. Black Stickleback.

This fish is abundant in streams and lakes in the northern part of Illinois, but has not been taken by us south of Rock River.

Its mouth is small; the gill-rakers are long and slender (about half as long as the corresponding filaments), but are not unusually numerous; the pharyngeal apparatus is insignificant or wanting; and the intestine is short and simple, not longer than the head and body together.

Four specimens from Rock River, and one from Cedar Lake, in Lake County, had divided their food about equally between plant and animal substances: the former, consisting wholly of filamentous Algæ, taken by four of the specimens in quantities to make it certain that they were ingested purposely. The animal food was about equally insects and crustaceans, the former nearly all aquatic larvæ of Diptera (Chironomus being the commonest form), and the latter chiefly Entomostraca, of which Cladocera were the most abundant. One of the specimens had eaten Cypris—some of them *Cypris vidua*. Cyclops was also noticed in three of the fishes, and amounted to three per cent. of the food.

The herbivorous character of this fish seems not to be related to any structural facts; but the occurrence of the large ratio of Entomostraca is at once accounted for by the well-developed gill-rakers, these serving as a straining apparatus by means of which the fishes possessed of it are able to appropriate minuter organisms than would otherwise be available for their food.

PYGOSTEUS PUNGITIUS, Lac. MANY-SPINED STICKLEBACK.

This species has hitherto been found by us only in Lake Michigan, and in Calumet River near its mouth.

But two specimens were dissected; and these had fed wholly on larvæ of Chironomus and Simulium (sixty per cent.), and on Chydorus and other Cladocera (forty per cent.).

With so small an amount of material to illustrate the food of the family, we can only say that it evidently consists chiefly of aquatic larvæ and Entomostraca, together with a considerable percentage of vegetable substances. In the absence of any apparatus for mastication, the latter will doubtless be found to consist of Algæ, as in the cases examined.

FAMILY ATHERINIDÆ.

LABIDESTHES SICCULUS, Cope. SILVERSIDES.

This elegant little fish, the only fresh-water representative of its family, is generally abundant throughout the State, and has been collected by us in a great variety of situations, from the northern lakes to the Wabash River.

It is long and slender, the mouth small and well furnished with

teeth, while the throat is destitute of special pharyngeal apparatus. The gill-rakers are unusually well developed, being numerous, slender, finely toothed, and longer than the corresponding filaments of the gills. Taking into account the small size of the fish, and the consequently small diameter of the apertures of the mouth and gills, it will be seen that it is provided with an especially effective straining apparatus. The intestine is unusually short, the entire alimentary canal measuring considerably less than the length of the body without the head.

The following account of its food is derived from the dissection of twenty-five specimens, obtained from Crystal Lake, Fox River, and Calumet River in Northern Illinois, from Peoria and Mackinaw Creek in the central part of the State, and from Little Fox River in the Wabash Valley. The food of these specimens was purely animal, a little over half consisting of insects, and a little less than half of crustaceans. The larvæ of Chironomus were among the most important elements of the food, standing at thirty per cent. of the whole. The crustaceans were all Entomostraca, and represented a great variety of both Copepoda and Cladocera, although none of the specimens examined happened to have eaten Ostracoda. Among the Cladocera recognized were *Daphnia pulex*, *retrocurva* and *hyalina*, *Simocephalus americanus*, Bosmina, Chydorus, Pleuroxus, Alona, and Eurycercus; and among the Copepoda were *Cyclops thomasi*, Canthocamptus, Diaptomus, Limnocalanus, and *Epischura lacustris.* Spiders and terrestrial insects, accidentally washed or fallen into the water (the latter including Chalcididæ, various Diptera, plant-lice, Tettigonidæ, Thrips, and Podura), amounted to twelve per cent. of the food. The only peculiarities of food corresponding to differences of locality were found among the group from the northern lakes, in which the Chironomus larvæ were present in diminished ratios, while the Cladocera were more abundant.

FAMILY CYPRINODONTIDÆ.

This family consists, in Illinois, of four species, one of Fundulus and three of Zygonectes.* The family is divided into two sections, *carnivorous* and *herbivorous*, by Dr. Günther in his "In-

*I do not consider *Fundulus menona*, Jor. and Cope., as distinct.

troduction to the Study of Fishes." Although our genera both belong to the carnivorous section, it will be seen that they are not by any means strictly confined to animal food, vegetation making about one-fifth of their usual nutriment.

FUNDULUS DIAPHANUS, LeS. BARRED KILLIFISH.

This species is very abundant in the northern part of the State, especially in lakes or in clear and sandy streams, but we have not taken it anywhere in Central or Southern Illinois. Most of our collections were made in the lakes of Lake and McHenry Counties.

The intestine is shorter than the body, the gill-rakers are short, obtuse, and few in number, the pharyngeal jaws are of the pavement type, set with fine, sharp teeth, and the mouth is small, but extraordinarily protractile.

Eight specimens were studied, from Crystal and Cedar Lakes. About four-fifths of the food consisted of animal substances, the remaining fifth of vegetation. Except a few filamentous Algæ taken by one of the specimens, the latter consisted wholly of seeds of various plants fallen into the water. Eighty per cent. of the food of two of the specimens, and twenty per cent. of that of a third consisted of such seeds; ratios evidently too large to have been taken accidentally. Two of the specimens had eaten Planorbis, and all had eaten insects, which made about forty per cent. of the food; terrestrial species, including spiders, making twelve per cent. Among the aquatic forms were Chironomus larvæ, Hydrophilidæ, and larvæ of Ephemeridæ, the latter eleven per cent. Crustacea were a fifth of the food, chiefly the abundant amphipod, *Allorchestes dentata.* Cypris and Candona were likewise noticed in considerable quantity (seven per cent.), and a few specimens of various Cladocera occurred.

ZYGONECTES NOTATUS, Raf. TOP MINNOW.

This species ranges in ponds and sluggish streams throughout the State, but is most abundant southwards. Here it may commonly be seen swimming slowly about in stagnant pools, with the head at the surface of the water, as if interested in the phenomena of the weather, or possibly watching for the appearance of terrestrial insects. The alimentary structures are in all respects similar

to those of Fundulus, except that the intestine is possibly a little longer, being about equal to the head and body. The only striking peculiarity is the depressed head, with the mouth placed at the upper angle and opening obliquely upward. This, with the surface-swimming habit of the fish, has given rise to the supposition that it feeds largely upon surface insects; but I did not find this to be the case, as the seventeen specimens studied contain no example of an insect of this character.

These specimens were taken from a considerable variety of situations throughout Central and Southern Illinois, and at various times of the year. The animal food amounted to about ninety per cent. of the whole. Vegetation, almost wholly filamentous Algæ, was taken by ten of the specimens, but in such quantities by various individuals as to make it certain that its presence was not accidental. In one, for example, the intestine was packed with these Algæ to the exclusion of all other food, and in three others this made more than half the whole. One specimen had also eaten Wolffia. Mollusks (Physa) had been eaten by three, and insects amounted to seventy-three per cent. Spiders and various terrestrial insects made fully a fourth of the food. Philhydrus, taken by three of the specimens, was reckoned at eight per cent. Corixa and other aquatic Hemiptera amounted to eleven per cent., and larvæ of Agrion to three. Crustacea were estimated at only six per cent. They included *Crangonyx gracilis*, and various Cladocera, Ostracoda and Copepoda. Among the Entomostraca recognized were Daphnia, Chydorus, Pleuroxus, Acroperus, Cypris, and Cyclops. Chironomus larvæ were about one per cent., taken by only two of the specimens.

Zygonectes inurus, Jor. and Gilb. Black-eyed Top Minnow.

Zygonectes dispar, Ag. Striped Top Minnow.

The first of these species is peculiar in this State, as far as known, to Southern Illinois, not having been taken by us north of White County. The second ranges throughout.

Six specimens of the first and two of the second were studied. The food characters presented do not differ sufficiently from those of *Zygonectes notatus* to make it worth while to treat them separately, and a summary for the genus will be given instead.

Four-fifths of the food of the genus consisted of animal matter, nearly one-quarter being Mollusca, including Physa, Planorbis, and *Valvata sincera.* Insects make less than half, and nearly half of these were of terrestrial origin. Chironomus larvæ, usually so abundant in the food of insectivorous minnows, occurred here in only trivial quantity. Specimens of Philhydrus were eaten by three of the fishes. *Corixa alternata* amounted to five per cent. of their food, Agrion larvæ and case worms (Leptoceridæ) to two per cent. Crustaceans were only four per cent. of the whole, partly Amphipoda, but chiefly Entomostraca. The vegetable food (sixteen per cent.) was chiefly Wolffia, taken by five of the specimens from southern lakes. Ten individuals had, however, eaten filamentous Algæ.

Summary.

The only essential difference between these two genera exhibited by the specimens studied, is the much larger ratios of terrestrial insects captured by Zygonectes, this genus eating nearly twice as many as the other. This fact is possibly related to the surface-swimming habit already mentioned, but is more likely due to the smaller bodies of water in which the top minnows occur. Concerning the food of the family as a whole, the salient characters are the presence of a considerable quantity of vegetable food, (about twenty per cent.) the occurrence of fifteen per cent. of Mollusca, the insignificant quantity of Crustacea eaten (four per cent.), and the importance of terrestrial insects as a source of support.

FAMILY UMBRIDÆ.

UMBRA LIMI, Kirt. MUD MINNOW.

This species, the only one of its family in Illinois, is very abundant in muddy ponds and ditches, and has been collected by us from Lake to Union Counties.

The intestine is short, less than the body in length; the gill-rakers are thick and rather long, about one-half the length of the filaments, and the pharyngeal apparatus is wholly insignificant.

Ten specimens were studied, from six localities, all from Southern Illinois but one, which was taken in Calumet River. Vegetable food amounted to forty per cent., chiefly Wolffia, eaten by

seven of the specimens from Southern Illinois lakes. A considerable quantity of unicellular Algæ was also taken by one. Mollusks, eaten by two, were reckoned at five per cent., all Physa. Insects drop to fourteen per cent., chiefly undetermined larvæ. No terrestrial forms were recognized. Corresponding to the greater development of the gill-rakers, we find the Entomostraca assuming greater importance in the food. These were reckoned at ten per cent.; three per cent. additional consisting of *Crangonyx gracilis.*

FAMILY CYPRINIDÆ.

This family includes all the fishes properly known as "minnows," embracing, in fact, by far the larger part of the smaller fishes of the State. Both in number and in variety of species it is much the most important family of fresh-water fishes. It includes, in Illinois, about forty species, nearly or quite one-fourth of the whole number known to occur in our territory. They occur in all waters from the Mississippi River and Lake Michigan to the smallest streams and ponds; but are much the most abundant in creeks and rivulets. The species differ greatly with respect to their favorite haunts, some affecting the principal lakes and larger rivers, others occurring most commonly in clear and rapid brooks, while still others are most frequent in the sluggish and muddy streams of prairie regions. The principal economic interest of the fishes of this family is due to the well-known fact that they furnish an important part of the food supply of larger species.

But little has hitherto been done upon their food in the United States. In fact, I have seen nothing more accurate or comprehensive than the following general statement made by Prof. Cope, in his paper on the Cyprinidæ of Pennsylvania:*

"These differences of habit are associated with peculiarities of food and of the structure of the digestive system. Few families of vertebrates embrace as great a variety in these respects as the present one. There are carnivorous, insectivorous, and graminivorous genera, which are distinguished as among mammalia, the former by the abbreviation, the last by the elongation of the ali-

*Trans. Amer. Philosophical Society, Vol. 13, New Series, page 353.

mentary canal, in the former the teeth are usually sharp-edged or hooked, in the latter truncate, hammer, or spoon-shaped."

"In the American genera, as far as included in the scope of this essay, the peculiarities of the intestines correspond with the food. In the *Alburnellus rubrifrons*,[1] they are but four-fifths the length of head and body (excluding caudal fin). In *Hypsilepis kentukiensis*,[2] *Photogenis leucops*, *Argyreus atronasus*[3] and *nasutus*,[3] *Ericymba buccata*, and *Exoglossum maxillingua*, about seven-ninths; the food of the last five species is insects and crustaceans, the last depending largely on mollusca. In the species of Ceratichthys, Semotilus, and Hybopsis, with *Hypsilepis cornutus*,[4] fifteen-sixteenths to equal the length; the habits insectivorous. The genera with longer intestines are, first, Stilbe[5] one and two-fifths to one and three-fourths the length; Chrosomus, Hyborhynchus, and Pimephales two and two-fifths to two and two-thirds, and Hybognathus four times. The intestines in these are generally filled with a soft, dark-colored slime, without remains of insects, but of vegetable origin. In the remarkable genus Campostoma the canal extends to between eight and nine times the length, and, like that of other vegetable feeders, is usually found occupied by the ingesta for a considerable part of its length."

This statement is in the main correct as far as it goes, but it will be seen from the following data, and from the discussion of the food of the family, that it is far from the truth with respect to the genus Campostoma and its allies.

If we examine the alimentary structures of the Cyprinidæ, to which reference has been made in describing the food of the preceding families, we shall find these fishes easily divided into at least four tolerably distinct groups, defined by characters drawn from the gill-rakers, the pharyngeal teeth and the intestines. In all but two of the genera of this paper* the gill-rakers are short and insignificant. The pharyngeal teeth may be either hooked or plain, and with or without grinding surface, while the intestine varies in length from less than that of the body without the head

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[1]Minnilus or Notropis. [2]Photogenis analostanus. [3]Rhinichthys. [4]Luxilus cornutus. [5]Notemigonus.

*I have used here, for convenience' sake, the nomenclature of the Catalogue of the Fishes of Illinois, published in our third bulletin.

to seven or eight times the length of the head and body together. For convenience' sake I have grouped the genera as follows:

Group I.—Intestine long. Pharyngeal teeth not or slightly hooked, with grinding surface.

Campostoma, *Pimephales*, *Hyborhynchus*, *Hybognathus.*

Group II.—Intestine rather long. Teeth hooked, with grinding surface.

Notemigonus, *Chrosomus.*

Group III.—Intestine short. Teeth hooked, with grinding surface.

Hybopsis, *Luxilus*, *Lythrurus*, *Hemitremia*, *Platygobio.*

Group IV.—Intestine short. Teeth hooked, without grinding surface.

Minnilus, *Photogenis*, *Ericymba*, *Phenacobius*, *Semotilus*, *Ceratichthys*, *Rhinichthys.*

The second group, consisting of Notemigonus and Chrosomus, may be again divided according to the development of the gill-rakers, which are numerous, long, and slender in Notemigonus; few, short, and insignificant in Chrosomus.

Food of the Young.

The genera and species of Cyprinidæ are not easily recognized, even in the adult, the characters upon which they are based being often either trivial or extremely variable; and when one has to do with individuals small enough to show the earliest food of the family, it is commonly quite impossible to identify even the genus. In the few specimens which I have studied, I have not attempted such determination, although I have reason to believe that most of those examined belong to some species of Minnilus.

Their food was so far peculiar, as compared with the young of other families, that I will describe in detail that found by dissecting six specimens under an inch in length. The first of these, three-eighths of an inch long, taken in Fox River on the 8th of July, had eaten only a small Chironomus larva, and a single example of Bosmina. Two specimens, six-tenths of an inch long, captured in August in a creek in Central Illinois, had derived their food from quite different sources. Filaments of Spirogyra and other filamentous Algæ, cells of Cosmarium and Closterium,

and Cymatopleura and other diatoms, and spores of Ustilago, were the vegetable elements, while the head of a Chironomus larva and great numbers of the ciliate infusorian *Euglena viridis*, and a few specimens of *Euglena acus*, represented the animal kingdom. Full half the contents of these intestines consisted of the Protozoa mentioned. A third specimen of the same length, taken from the Illinois River in June, had derived about eight-tenths of its food from Bosmina, the remainder consisting of a small Chironomus larva and a minute larval hydrachnid. In a specimen seven-tenths of an inch long, taken in Mackinaw Creek in August, *Euglena viridis* was the most abundant object, making about six-tenths of the food; and *Euglena acus* and a species of Phacus also occurred. Various filamentous Algæ, specimens of Closterium and Cosmarium, and numbers of diatoms were the remaining elements. In another specimen, taken at the same time and place, about three-fourths of an inch in length, fungi and fungus spores amounted to more than half the food, although the same forms of Algæ occurred as before, together with a few examples of *Euglena viridis* and Difflugia. A Chironomus larva, a plant-louse, and some other insect not determined, had also been eaten.

From the above we may conclude that the young Cyprinidæ draw almost indiscriminately, for their food supply, upon Protozoa, Algæ, and Entomostraca, differing in this respect from the young of all the other families which I have studied, with the exception of the Catostomidæ. It is worthy of note, as a suggestive coïncidence at least, that the other families just mentioned which were found to take Entomostraca and Chironomus larvæ as their earliest food, were all possessed of raptatorial teeth on the jaws when very young; whereas in young suckers and Cyprinidæ, the mouth is unarmed at all ages.

Group I.

Intestine long. Pharyngeal teeth not hooked, with grinding surface.

Campostoma anomalum, Raf. Stone Lugger.

This very peculiar fish is exceedingly abundant everywhere except in the great lakes. I have taken it in streams of all magnitudes, from the Illinois River to the smallest creeks, but have not yet encountered it in Lake Michigan or in stagnant pools. It is commonest, however, in swift creeks of medium size.

It is distinguished from all other species by the great length of the intestine, which is from six to nine times the length of the body, and is spirally coiled about the air bladder. The gill-rakers are numerous, about twenty in number to each gill, but are very short, scarcely projecting beyond the anterior margin of the arch. They are evidently almost totally inefficient as a straining apparatus.

Of the great number of specimens available for dissection, only nine were studied, since the contents of the intestines were found so uniform in character that it was not deemed worth while to multiply instances. These were from both extremes and also from the center of the State, but were all taken in July, August and September. The intestine was invariably filled from end to end with a black and slimy matter, which, when examined under the microscope, was found to consist almost wholly of fine mud. When the intestine was emptied and the contents stirred up in alcohol and repeatedly decanted so as to separate the coarser fragments, the organic matter was easily distinguished. It made on an average, only about one-fourth of the contents of the intestine, the remainder consisting of the finest particles of sand and clay. Not far from one-fifth of the whole amount was of vegetable origin, consisting chiefly of filamentous Algæ, mingled with a few diatoms, but comprising occasionally minute fragments of other kinds of vegetation also. The only animal objects noted were occasional Chironomus larvæ and Difflugia. Sometimes the intestine was wholly filled with almost pure mud, in which no organic structures whatever could be detected. Date and locality seemed to make no material difference in the food of this fish, which should evidently be classed as limophagous. The ratios of animal to vegetable food were scarcely different from what one would expect to find in the intestine of a fish which had the habit of swallowing mud rich in organic matter, the greater ratios of vegetation being apparently due to the fact that plants are more abundant in the water than animals.

PIMEPHALES PROMELAS, Raf. BLACK HEAD.

This species is generally distributed throughout Central and Northern Illinois, but is not very abundant. We have taken it only in rivers and larger creeks, but have not found it south of Jersey County.

The alimentary canal is two or three times the length of the body, and the gill-rakers are fifteen in number and somewhat more prominent than usual, those on the posterior part of the first arch being about one-third the length of the corresponding filaments.

Only four specimens were studied, one from the Pecatonica River at Freeport, and three from Otter Creek in Jersey County. With this fish as with the preceding, about three-fourths of the contents of the intestine consisted of mud, the remainder being almost wholly insects. These were partly terrestrial species, occurring accidentally in the water, and partly aquatic larvæ of Diptera. The vegetable food of these specimens amounted only to about one per cent., chiefly various unicellular Algæ.

HYBORHYNCHUS NOTATUS, Raf. BLUNT-NOSED MINNOW.

This extremely abundant minnow occurs in streams and rivers throughout the State, but has not been found by us in ponds. Specimens were taken, however, in the small lakes of Northern Illinois.

The intestine is about two and one-half times the length of the head and body. The gill-rakers are few, short and thick, being about one-fifth of the length of the corresponding filaments.

Nine specimens were studied from all parts of the State, when their food proved to be so uniform in character that further observations were deemed unnecessary. Mud made about eighty per cent. of the contents of the alimentary canal, the remainder consisting of unrecognizable vegetable debris, with a few filaments of Algæ. Undeterminable insects occurred in one, and a single specimen of Cypris in another.

HYBOGNATHUS NUCHALIS, Ag. BLUNT-JAWED MINNOW.

This species is likewise generally distributed in rivers, creeks and ponds, occurring in our collections from Galena to Cairo, and at a great number of points intermediate.

The alimentary canal in this genus is elongate, being about four times the length of the body. The gill-rakers are few and rather short, triangular in form, and about one-fourth to one-fifth the length of their corresponding filaments.

Eight specimens of this species were dissected, with results in

all respects similar to those given for the other members of this group. Filamentous Algæ, diatoms, and a few accidental fungus spores, were the only objects found imbedded in the quantities of mud which filled each intestine.

Summary of the Group.

If we average the results of the four species studied, belonging to this first group, we shall find that about three-fourths of the contents of the stomach and intestine consist of soft, black mud, the remaining fourth being derived from both animal and vegetable substances, about three times as much from the latter as from the former. The animal food is chiefly insects, both terrestrial and aquatic, and the vegetation is divided about equally between Algæ and miscellaneous fragments of higher plants. This group, with long intestine and grinding pharyngeals, is consequently to be considered as essentially limophagous. We find this peculiar form of pharyngeal teeth associated only with intestines of this type.

Group II.

Intestines moderately long; pharyngeal teeth hooked, with grinding surface.

Chrosomus erythrogaster, Raf. Red-bellied Dace.

This species is locally abundant, although not generally common. It occurs in clear streams in the northern part of the State, but has not been taken by us in Central or Southern Illinois.

The length of the fish is contained one and two-thirds times in the length of the intestine; the gill-rakers are few and rather short, triangular, acute, and about one-fifth the length of the corresponding filaments.

I examined carefully but three specimens of this species, derived from two localities. These were alike in the presence of great quantities of mud, which amounted to about eighty-seven per cent. of the contents of the intestine. The animal food was confined to a trace of Cladocera. The vegetation amounted to thirteen per cent., partly tissues of aquatic plants, with traces of fungi, but chiefly Algæ of various forms, including a little Oscillatoria.

NOTEMIGONUS CHRYSOLEUCUS, Mitch. SHINER.

This extremely abundant minnow, commonly called the shiner, occurs in all waters throughout the State, from the largest rivers to the smallest creeks, and from Lake Michigan to small stagnant ponds.

The intestine is shorter than in any of the preceding species, although still rather long, the head and body being contained one and one-third times in its length. The gill-rakers are long, fine, and numerous, about twenty in number on the anterior arch, and fully one-third the length of the corresponding filaments, making, therefore, an effective apparatus for the separation of the Entomostraca from the water. As this fish presents a peculiar combination of alimentary structures, and as its food was found unusually various, a larger number of specimens were studied than of any of the species already discussed.

Twenty-five fishes were dissected, from a great variety of situations in all parts of the State, and representing various dates from May to September inclusive. As the food differed widely according to situation, that of specimens from certain localities being more widely different than the food of different species has usually been found, it will be best to mention the most conspicuous differences depending upon situation.

Specimens taken from the Pecatonica River at Freeport, an extraordinarily muddy stream, noted for the abundance of its mollusks, had eaten no other food than univalve Mollusca, chiefly *Valvata tricarinata* and *Planorbis deflectus*. Another, from the Illinois River at Pekin, had also eaten largely of mollusks, while three taken in Otter Creek in Jersey County, in almost stagnant reaches of the stream, extremely muddy, and green with Algæ, had filled their intestines with mud, like Campostoma; and still others from ponds near Normal had eaten only Entomostraca, about equally Cladocera and Copepoda. Another specimen from the Illinois River had taken similar food, all Daphnias. One specimen from Nippersink Lake, in the northern part of the State, was full of wild rice (Zizania). Taking all these groups together, and considering the species as a whole, besides the mud already mentioned, about fourteen per cent. of the food consisted of mollusks, and only six per cent. of insects, nearly all of which were of

terrestrial species. Crustaceans amounted to fifteen per cent., all Entomostraca. Vegetation stands at fifty per cent., more than half of it accidental vegetable debris, partly from aquatic and partly from terrestrial plants. About one-fifth of the food consisted of Algæ, half of which was filamentous in character, and the remainder desmids, including Closterium, and various diatoms.

The peculiar character of the alimentary structures of this species are very clearly reflected in this summary of its food, the elongate intestine corresponding to the presence of mud, and the well developed gill-rakers to the occurrence of Entomostraca. I have not yet noticed any structural peculiarity of the Cyprinidæ related to the habit of feeding upon mollusks.

Summary for the Group.

The two species foregoing agree only in their mud-eating propensity,—probably habitual in one and occasional in the other,—the first having the longer intestine, and the second the longer gill-rakers. To this last difference we doubtless must trace the different relations of these fishes to Entomostraca.

I find nothing whatever, by comparison of the food of these specimens with those of the preceding group, to show the meaning of the hooked form of the pharyngeal teeth.

Group III.

Intestine short, teeth hooked, with grinding surface.

This group includes Hybopsis, Luxilus, Lythrurus, Hemitremia, and Platygobio. My studies were limited to three genera: Hybopsis, Luxilus and Hemitremia.

Hybopsis hudsonius. Clint. Spawn-eater.

This fine minnow is common everywhere to the northward, especially in Lake Michigan and the other lakes of Northern Illinois, but not abundant south of the central part of the State, although it has been taken to its extreme southern limit. It has never occurred in our collections in the smaller streams, but is confined to the lakes, rivers, and creeks of some magnitude.

The gill-rakers of this minnow are short and few.

Seventeen specimens were studied, from Lake Michigan,

Nippersink Lake and the Illinois River. Mud was found in noticeable quantities only in a single specimen, and there in small amount. About seventy per cent. of the food consisted of animal substances, three per cent. being fishes, taken by two of the minnows. One had also eaten a small bivalve mollusk. Insects made half the food, about one-third of them of terrestrial species (Rhynchophora), the remainder being chiefly larvæ of ephemerids. A few Chironomus larvæ and an aquatic hemipter, were the only other kinds determined. Crustacea amounted to thirteen per cent., nearly all Ostracoda (*Cypris vidua*) taken by two of the specimens from Chicago. Vegetable food stands at thirty-one per cent., eaten by ten of the specimens. One-third of this consisted of Algæ, chiefly of the filamentous forms, the remainder being miscellaneous fragments of exogenous plants, chiefly evidently aquatic.

Local and individual peculiarities.—The general summaries of the food of so many individuals from so great a variety of situations often disguise interesting and important facts relating to the food resources of the species, since an element taken in large quantity by one or two specimens may figure in the general average in such an insignificant ratio as to lead to the inference that its occurrence is merely accidental. In other words, general averages for a variety of situations will not necessarily indicate all the food resources open to the species. These can only be demonstrated by exhibiting the *peculiarities* of the record as well as its general average characters. For example, the fact that only eleven per cent. of the food of this species consisted of Algæ has a somewhat different aspect when we learn that one of the specimens had eaten nothing else, and that they made three-fourths of the food of another. Three specimens had eaten only insects, and these made ninety per cent. or more of the food of three others. Two had eaten nothing but Entomostraca, all the *Cypris vidua* previously mentioned. Vegetable structures made the entire food of four, and ninety per cent. or more of the food of three other specimens. Three out of four individuals taken at Nippersink Lake in May, had derived from ninety to one hundred per cent. of their food from terrestrial beetles of a single family (Rhynchophora), while ephemerid larvæ occurred in the food of three others in ratios exceeding seventy-five per cent.

HYBOPSIS STRAMINEUS, Cope. STRAW-COLORED MINNOW.

This insignificant species has been found by us in rivers and small streams throughout the State.

The gill-rakers were few and short.

Only five specimens were studied, all from rivers in Central Illinois. About three-fourths of their food consisted of animal matter, nearly all neuropterous larvæ (fifty-eight per cent.), Ephemeridæ standing at forty-eight per cent., and case-worms at ten. Crustacea were ten per cent., all Cyclops except a trace of Canthocamptus. About one-fourth of the food was vegetation, chiefly seeds of grasses, occurring, of course, only accidentally in the water. Two had derived from ninety to one hundred per cent. of their food from ephemerid larvæ, and four of the five had eaten vegetation amounting to as much as eighty per cent.

LUXILUS CORNUTUS, Raf. SHINER.

This large and fine minnow is probably the commonest fish in Illinois, occurring in lakes and streams of all sizes everywhere throughout our limits.

The gill-rakers are short and few, and of insignificant development, and the intestine is shorter than the head and body.

Twenty-one specimens were studied, from all parts of the State and at various seasons of the year. Animal food amounted to two-thirds of the whole, fourteen per cent. being fishes, eaten, however, by only one of the specimens. Insects, eaten by nineteen, were reckoned at forty-five per cent., only one-fourth of them terrestrial. Gyrinid larvæ, Corixa, and larvæ of *Palingenia bilineata* were among the forms recognized. The crustacean ratio was insignificant, standing at only three per cent., all the abundant amphipod, *Allorchestes dentata*, with the exception of traces of a considerable variety of Entomostraca, including Chydorus, *Acroperus leucocephalus*, and Cypris. One of the water-worms (Lumbriculus) was noticed in a single specimen. Vegetable food was reckoned at thirty-eight per cent., only about one-third of it consisting of Algæ, and the rest of accidental fragments, including the seeds, anthers, and pollen of plants, with a little Potamogeton and various forms of fungus spores. One of the commonest of the Algæ was *Cladophora glomerata*,* taken

*Kindly determined for me by Rev. Francis Wolle, Bethlehem, Pa.

by those from Effingham. The fact has already been noted that one of the specimens had eaten only fishes. Five had confined themselves to an insect diet, while twelve had derived more than half their food from the vegetable kingdom, one of them eating ninety-five per cent. and another one hundred.

HEMITREMIA HETERODON, Cope. NORTHERN HEMITREMIA.

This species, extremely abundant in Northern Illinois, has not been taken by us south of the central part of the State. North of Rock River it has been generally found in streams and lakes of all descriptions, from Lake Michigan down.

The gill-rakers are few in number, but thick, triangular, and rather long, those on the posterior part of the arch being from a fourth to a third the length of the filaments. The intestine is contained one and one-fourth times in the length of the head and body.

Eighteen specimens were studied, suitably distributed as to time and place. A little mud was found in the stomach of one. Only about one-tenth of the food consisted of vegetation, chiefly flowers and seeds. Traces of filamentous Algæ occurred in two of the specimens. Univalve Mollusca were noticed in one, and insects in twelve, amounting to more than a fourth of the entire food. These were chiefly larvæ of Chironomus (twenty per cent.), ephemerid larvæ occurring in but one. Crustacea were reckoned at fifty-eight per cent., all Entomostraca, with the exception of a single *Allorchestes dentata.* About two-thirds of these were Cladocera, the remainder being Ostracoda and Copepoda. Rotifers and Protozoa also rarely occurred, the latter including Centropyxis and Difflugia. Five of the specimens had eaten Entomostraca only, and two others ninety per cent. or more. Only two had derived more than half their food from vegetable sources.

It will be seen that the peculiar fact with respect to this species was the large per cent. of Entomostraca appropriated. I find nothing in the structure of the fish to explain this circumstance, other than the somewhat unusual development of the gill-rakers and the small size of the species. The latter probably had more to do with it than anything else. It should be noted, however, that nearly half the specimens were derived from places where Entomostraca were excessively abundant at the time of their capture.

Summary of the Group.

Taking now this group as a whole, we remark, first, the absence of mud mingled with their food, as related to the greatly diminished length of the alimentary canal. We have now also a decided predominance of animal food, which is about three-fourths of the entire amount, and note likewise the first occurrence of fishes. Although Mollusca occur in this group, it is in quantity too small to appear in the ratios. Insects make about half the food of all, nine per cent. being terrestrial forms. The larvæ of Neuroptera are by far the most important insect species, and stand at twenty-five per cent. Entomostraca make a fifth of the whole food, distributed among all the orders. The vegetation eaten was largely of a purely miscellaneous and incidental character, only about a third of it being derived from aquatic plants.

Group IV.

Intestine short; teeth hooked, without grinding surface.

This group, organized more strictly for predatory purposes than any of the preceding, contains also the largest number of genera, embracing nine of those occurring in Illinois. It was not thought necessary to study all of these, and my dissections were confined to five of them, namely: to Minnilus, Photogenis, Phenacobius, Semotilus and Ceratichthys.

Minnilus atherinoides, Raf. Emerald Minnow.

This species is everywhere abundant in streams and lakes, but does not occur in ponds. It is most common northward, swarming in summer along the shores of Lake Michigan.

The gill-rakers are short, triangular, and about one-fourth the length of the filaments; and the intestine is less than the length of the head and body.

Eighteen specimens were studied, all from the northern half of the State. The food was almost strictly animal, but five per cent. consisting of vegetation, and this chiefly of accidental character, occurring in trivial ratios. Only a single specimen had taken about forty per cent. of its food from filamentous Algæ. A minute fish had been eaten by one of these minnows. Insects

made two-thirds of the food, nearly two-thirds of them being terrestrial. Neuropterous larvæ were the principal aquatic forms, chiefly case-worms and larvæ of ephemerids. The Crustacea (twenty-two per cent.) were all Entomostraca, about two-thirds of them Cladocera, the remainder Copepoda. Among the former Bosmina and Chydorus were recognized, and Diaptomus among the latter.

Six of this species had eaten only insects, and these made ninety per cent. of the food of two others. One had filled itself with the larvæ of *Bibio albipennis*, a terrestrial grub abundant in early spring. Three from Peoria Lake, captured in October, had eaten Cladocera only, nearly all a single species, *Bosmina longirostris.*

PHOTOGENIS ANALOSTANUS, Grd. SILVER FIN.

Excessively abundant in streams of all sizes.

The gill-rakers are short, triangular, about one-fourth of the length of the filaments. The intestine is shorter than the head and body.

Thirty-three specimens of this species were examined. Two-thirds of the food was insects, seven per cent. fishes, taken by three individuals, and one per cent. spiders, bringing the ratio of animal food up to seventy-one per cent. Besides these, a Limnæa was eaten by one, and traces of Cladocera and Copepoda occur in three. Nearly half the insects were terrestrial, Corixa and neuropterous larvæ being the most important aquatic forms. The vegetable food (twenty-nine per cent.) was nearly all of terrestrial origin, about one-third consisting of Algæ, both filamentous and unicellular, including Spirogyra and Glœocystis. Seeds, anthers and pollen of plants, and fragments of grass-like vegetation were noticed.

Eight of the specimens had taken only insects, and in two others these amounted to ninety-five per cent. Two had fed upon terrestrial species only. Corixa made ninety-five per cent. of the food of one. One had fed solely upon filamentous Algæ, and ninety per cent. or more of the food of three others consisted of vegetable structures in general.

PHENACOBIUS SCOPIFERUS, Cope.

This species occurs not very abundantly throughout the State, from Galena to extreme Southern Illinois. It has been taken by us almost invariably in swift and shallow streams.

The mouth is small and inferior, provided with fleshy lips somewhat resembling a sucker's in form. The gill-rakers and pharyngeal teeth are as usual in this group and the intestine is contained once and a half in the length of the head and body.

The nine specimens studied were from five localities, distributed from Galena to Union county. The food was almost purely insects, only two per cent. being unrecognized vegetation. Seventy-six per cent. consisted solely of Chironomus larvæ, and six per cent. of case-worms. Adult chironomids, taken by two of the specimens, amounted to two per cent. A few Cyclops found in a single specimen were the only Crustacea eaten by these fishes.

The peculiar character of this food, almost precisely that of a darter, is evidently related to the habitat of the fish.*

SEMOTILUS CORPORALIS, Mitch. CHUB.

This is a widely distributed and very abundant fish, perhaps the commonest species in the small creeks; but is less abundant in lakes and ponds.

The head and mouth are unusually large for a minnow; the intestine is six-sevenths the length of the head and body; and the gill-rakers are of the usual form.

Twenty-two specimens, from widely separated localities, give a ratio of seventy-six per cent. of animal food, four per cent. being fishes (partly Cyprinidæ), thirteen per cent. vegetation, and three per cent. worms. Insects make a little over half the whole, about one-half of them terrestrial. No Chironomus larvæ were found in the food of these fishes. Of neuropterous larvæ only a trace occurred, aquatic Coleoptera were noted in two, and Corixa in one. Grasshoppers (Acrididæ) made ten per cent. of the whole and were eaten by three of the specimens. Five had taken crawfishes, which made twelve per cent. of the entire food. No Entomostraca were noted, with the exception of one per cent. of Cyclops

*For a discussion of this matter, see Bulletin 3 of this series, p. 25.

occurring in two of the specimens. Numerous examples of Gordius were found in two, and were reckoned at three per cent. of the food.* The vegetable food (twenty-four per cent.) was half Algæ, the remainder miscellaneous vegetable debris.

Eight had eaten only insects, two having filled themselves with grasshoppers. Three from a prairie stream near Normal had taken only crawfishes, while of four specimens captured in McLean County in July, filamentous Algæ composed ninety-four per cent. of the food.

CERATICHTHYS BIGUTTATUS, Kirt. HORNED CHUB.

This species is everywhere abundant northward, chiefly, like Semotilus, in the smaller streams, but preferring swifter waters. We have not taken it, however, south of the center of the State.

It differs from the preceding members of the group by the greater length of its alimentary canal, which considerably exceeds the head and body, the latter being contained in the intestine about one and one-fourth times. The gill-rakers are not peculiar.

Thirteen specimens from Northern and Central Illinois had derived less than half their food from the animal kingdom. Only about one-fourth of it consisted of insects, largely case-worms and other neuropterous larvæ, another fourth being Crustaceans (crawfishes), eaten, however, by only two of the specimens. The vegetable food (fifty-four per cent.) was about equally divided between filamentous Algæ and seeds of Setaria and other grass-like plants.

Notwithstanding the small ratio of insects figured out, it is worthy of note that two specimens out of four captured in a creek in September had eaten only insects, chiefly case-worms, while these composed ninety-five per cent. of the food of another. As the intestines of these fishes contained a considerable quantity of gravel, it is evident that they had fed upon the bottom in rather swift water. On the other hand, two specimens had derived all their food from vegetable sources, and three others had eaten eighty per cent. or more of vegetation. The extraordinary amount of vegetation in the food of this fish is possibly related to the increased length of the alimentary canal.

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*These were not from the same specimens as those containing the grasshoppers.

Summary for the Group.

Ninety-five specimens of Group IV examined, representing five genera, had derived about three-fourths of their food from the animal kingdom, three per cent. of it being fishes, sixty-one per cent. insects, one per cent. Arachnida, and eleven per cent. Crustacea. One-third of the insects and spiders belong to terrestrial species. Chironomus larvæ are among the most important aquatic elements, amounting to sixteen per cent.; neuropterous larvæ coming next (eleven per cent.). About two-thirds of the crustaceans were crawfishes, the remainder being Cladocera and Copepoda. The vegetation (nearly one-fourth of the entire food) was chiefly of miscellaneous origin, nine per cent. only being recognizable as of aquatic forms. This was almost entirely filamentous Algæ.

Concerning this fourth group it may consequently be said, roughly, that the food consists of insects, crustaceans, and vegetable debris, about two-thirds of it the first, one-fourth of it the last, and one tenth, the other.

Summary for the Family.

If we regard the two hundred and fourteen specimens of fourteen genera which I have studied, as fairly representative of the family Cyprinidæ, and strike a separate balance of their food, we shall find that about thirty per cent. of the contents of the alimentary canal consists of mud; that one-half of it, or a little less, is animal matter, and that vegetation amounts to about one-fourth. Insects make one-third of the entire food, about ten per cent. being terrestrial species, eight per cent. Chironomus larvæ, and an equal number larvæ of Neuroptera. Of aquatic Coleoptera we have only a trace, and of aquatic Hemiptera (Corixa) but one per cent. Crustacea stand at ten per cent., nearly half of them Cladocera, Entomostraca as a whole amounting to about three-fourths of the crustacean ratio. Fishes are only two per cent., and mollusks less than one. Nearly half the vegetable food consists of Algæ (chiefly filamentous forms), the remainder being miscellaneous structures, derived from a great variety of plants, mostly terrestrial.

Summing up, in a word, the characteristics of the food of the family as thus indicated, we may say that about one-half of it consists of animal substances, one-third being insects, and one-third of these of terrestrial species, and ten per cent. being crustaceans; that one-fourth consisted of vegetation, about equally aquatic and terrestrial, and that the remainder is mud, probably containing more or less fluid organic matter.

Comparison of the Groups.

It will be remembered that the groups were based upon differences in the structures relating to the appropriation and mastication of food. It is consequently from a comparison of the ratios of these groups that we shall derive the most interesting facts relating to the correspondence of food and structure. The most conspicuous result is the great preponderance of mud in the intestines of the fishes of the first group, characterized by an extraordinarily elongate intestine, and by pharyngeal teeth destitute of hooks and provided with a broad grinding surface. Here, as already noted, mud, sand, and gravel amounted to about three-fourths of the matter ingested, while in the third and fourth groups only trivial and accidental quantities occurred. In the second group, on the other hand, with intestines intermediate in length, mud was still abundant, but much less so than in the first, averaging less than half the whole. If we exclude this indigestible matter, however, we shall find the first group still further distinguished by the predominance of vegetation as compared with animal matter, the latter being only about one-third the former, while in Groups III and IV, on the other hand, vegetation amounts to about one-third the animal food. The groups last mentioned, distinguished from each other as they are, only by the presence of a masticatory surface on the pharyngeal teeth in the first, and its absence in the second, differ scarcely at all in their general food characters, and this structural feature seems therefore to be of little significance. In both the animal ratio amounts to seventy-five per cent., and vegetation stands in each at twenty-five; while insects are respectively fifty and sixty-one. It is true that we find neuropterous larvæ greatly predominant in the first group, making one-fourth of their food, and Chironomus larvæ in the second amounting to sixteen per cent. The second of

these facts we find upon analysis to be evidently due to Phenacobius, by which genus nearly all the Chironomus larvæ were taken; and this, as already shown, is explained not by any structural feature, but by its peculiar habitat; and when we note that aquatic larvæ together amount in Group III to twenty-five per cent., and in Group IV to twenty-seven, we see that the significance of the difference mentioned disappears. A similar explanation is found of the difference in the ratios of Entomostraca,—that of the first group amounting to twenty per cent. and that of the second only to four. An examination of the tables shows that this predominance in the group first mentioned is nearly all traceable to Hemitremia, a very small fish with rather elongate gill-rakers.

The importance of these gill structures is still more clearly indicated, as already noticed, by the difference between Notemigonus and Chrosomus of the second group, and clearly far outweighs the structure of the teeth as an indication of the food habits of the fish.

The general conclusions reached may be thus briefly stated: An extraordinarily elongate intestine indicates the limophagous habit, rather than an especial preference for vegetable food. The length or number of the gill-rakers has much to do with the abundance of Entomostraca and other minute animal forms in the food of the fish, while the presence or absence of the terminal hook or the masticatory surface to the pharyngeal teeth is not thus far shown to have any sensible influence upon the general average of the food. Finally, a species may depart widely in food characters from those more nearly allied to it in structure, if its favorite haunts are peculiar.

TABLE OF FOOD: APHREDODERIDÆ TO UMBRIDÆ.

	Aphredoderus sayanus.	Potamocottus meridionalis.	Gasterosteidæ.	Labidesthes sicculus.	Fundulus diaphanus.	Zygonectes notatus.	Zygonectes inurus.	Zygonectes dispar.	Summary of Cyprinodontidæ.	Umbra limi.
No. of Specimens Examined	19	6	7	25	8	17	6	2	33	9
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.									
ANIMAL FOOD	.99	1.00	.75	1.00	.81	.90	.63	1.00	.70	.59
I. FISHES	.02	.27		.01		*			*	
II. MOLLUSCA				.01	.02	.03	.42	*	.15	.05
Univalves					.02	.03	.42	*	.15	.05
Bivalves				.01						
III. INSECTS	.91	.44	.44	.54	.37	.73	.18	*	.43	.14
Aquatic larvæ	.08	.36								
1. *Hymenoptera*				.01	.04	.08	.02		.05	
2. *Diptera*	.45	.01	.43	.46	.14	.21	.07	*	.14	*
Terrestrial				.30	.01	.02			.01	
Brachycera				.04		.01			.01	
Chironomidæ				.25	.01	.01			†	
Aquatic (larvæ)	.43		.37	.05	.02	*			.01	
Culicidæ	†					*			*	
Corethra	.07									
Chironomus	.36		.17	.05	.02				.01	
Simulium			.20							
3. *Coleoptera*	.11				.06	.17			.08	
Terrestrial	.11									
Aquatic larvæ					.03	.08			.04	
Hydrophilidæ						.08			.03	
Philhydrus					.03	.04			.02	
4. *Hemiptera*	.02			.01	.02	.17	.08	*	.09	.03
Terrestrial				.01	.02	.05	.05		.04	
Aquatic						.11	.01	*	.04	
Corixa	.02					.10		*	.03	
5. *Neuroptera* (larvæ)	.25			.06	.11	.03	.01		.05	
Ephemeridæ	.14				.11				.04	
Palingenia	.07									
Odonata				.06		.03			.01	
Agrion				.01		.03			.01	
Libellulidæ	.11									
Leptoceridæ							.01		†	
6 *Thysanura* (Podura)				†						
IV. ARACHNIDA			.01	.03	.02	.03			.02	*
Terrestrial			.01	.03	.02	.03			.02	
Hydrachnidæ				†	†				†	*
V. CRUSTACEA	.04	.29	.30	.40	.21	.06	.03	*	.10	.13
1. *Amphipoda*	.03				.13	*	.02		.05	.03
2. *Isopoda* (Asellus)	.01	.29								
3. *Cladocera*			.28	.24	.01	.02	†	*	.01	.06
Daphniidæ			.14	.23		.01				
Lynceidæ			.14	.01	.01	†		*		
4. *Ostracoda*	†		.01		.07	.02			.03	.04
5. *Copepoda*	†		.01	.16		.02	.01		.01	
VI. VERMES (*Chætopoda*)	.02									
VII. Protozoa							†		†	
VEGETABLE FOOD	.01		.25		.19	.10	.37		.17	.41
Seeds					.18	.01			.05	
1. *Endogens*	†						.34		.09	.33
2. *Algæ*	.01		.25		.01	.09	.03		.03	.08

TABLE OF FOOD OF CYPRINIDÆ.

	Campostoma anomalum.	Pimephales promelas.	Hyborhynchus notatus.	Hybognathus nuchalis.	Summary of Group I.	Notemigonus chrysoleucus.	Chrosomus erythrogaster.	Summary of Group II.	Hybopsis hudsonius.	Hybopsis stramineus.	Luxilus cornutus.	Hemitremia heterodon.	Summary of Group III.	Minnilus atherinoides.	Photogenis analostanus.	Phenacobius scopiferus.	Semotilus corporalis.	Ceratichthys biguttatus.	Summary of Group IV.	Summary of Cyprinidæ.
No. of Specimens	9	4	9	8	30	25	3	28	17	5	21	18	61	18	33	9	22	13	95	
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.																			
ANIMAL FOOD		.27			.07	.35	†	.18	.69	.76	.62	.87	.73	.95	.71	.98	.76	.46	.77	.48
I. FISHES									.03		.14		.04	.03			.04			.02
II. MOLLUSCA						.14		.07	.01			†	†		†					
Univalves						.14		.07				†	†		†					
Bivalves									.01				†							
III. INSECTS	†	.25	†		.06	.06		.03	.51	.66	.45	.29	.48	.67	.63	.98	.56	.24	.61	.34
Terrestrial											.03		.01	.02	*				.01	.10
Aquatic											.02	†	†		.01		.12	.03	.03	
1. *Hymenoptera*											.02		.01	.05	.04		10		.04	
2. *Lepidoptera*		.15			.04	.03		.01			†		†	.01	.05		.01	.03	.02	
3. *Diptera*	†	.10			.02	†		†	.03	.05	.04	.24	.09	.14	.26	.78	.08	.01	.25	
Terrestrial												.01	†	.11	.18	02	†		.06	
Chironomidæ												.01	†			.02				
Aquatic (larvæ)	†				†	†		†	.03			.20	.06	.02	.06	.76		.01	.17	
Chironomus	†				†	†		†	.03			.20	.06		.03	.76		.01	.16	.08
Simulium														.02	.02					
4. *Coleoptera*						.02		.01	.18		.06		.06	.13	.02		.10	.01	.05	
Terrestrial						.02		.01	.18		.05		.06	.13	.01		.05	.01	.04	
Carabidæ														.04			.01		.01	
Aquatic											01		†				.03		.01	†
Haliplus																	.02		.01	
Gyrinidæ (larvæ)											.01		†							
Hydrophilidæ																	.01		†	
5. *Hemiptera*						.01		.01	.01		.02		†	.11	.10		.03		.05	
Terrestrial											†		†	.05	.01				.01	
Aquatic						.01		01	.01		.01		.01	.05	.08		.03		.03	.01
Corixa											.01		.01		.08		.03		.02	
6. *Orthoptera*																	.12		.02	
7. *Neuroptera*									.28	.58	.10	.03	.25	.17	.10	.14		.16	.11	.08
Larvæ											.04		.01		.01	.08		.03	.02	
Pupæ															.03				.01	
Ephemeridæ									.28	.48	.06	.03	.21	.10	.01			.01	.02	
Phryganeidæ										.10			.03	.07	.05	.06		.12	.06	
IV. ARACHNIDA						†					†	†	†	.02	.01				.01	
V. CRUSTACEA			†		†	.15	†	.08	.13	.10	.03	.58	.21	.22	†	†	.13	.22	.11	.10
1. *Decapoda* (Crawfish)																	.12	.22	.07	
2. *Amphipoda*											.03	.01	.01							
3. *Cladocera*						.10	†	.05	.01		†	.36	.09	.15	†				.03	.04
Sididæ (Daphnella)												.01	†							
Daphniidæ						.10		.05				†	†	.12	†				.02	
Lynceidæ						*		*	.01		†	.35	.09	†	†				†	
4. *Ostracoda*			†		†	*		*	.12		†	.04	.04							.01
5. *Copepoda*						.05		.03		.10		.17	.07	.07	†	†	.01		.01	.02
VI. VERMES		.02			.01						†	†	†				.03		.01	
Lumbriculus											†		†							
Naidæ		.02			.01												.03		.01	
Gordius																				
Rotifera												†	†							
VII. PROTOZOA	†				†							†	†							
VEGETABLE FOOD	.20	.01	.20	.25	.18	.50	.13	.31	.31	.24	.38	.11	.26	.05	.29	.02	.24	.54	.23	.23
Miscellaneous	.02	†	.15		.09	.21	.02	.11	.10	.01	.05	.03	.05	.01	.06	.02	.10	.02	.04	
1. *Fungi*				†	†		†	†			†		†							
2. *Algæ*	.18	.01	.05	.25	.09	.19	.09	.14	.11		.12	.01	.05	.01	.09		.12	.23	.09	.10
MUD AND GRAVEL	.75	.72	.80	.75	.75	.15	.87	.51	†			.02	.01			†			†	.29

THE FIRST FOOD OF THE COMMON WHITE-FISH.

(Coregonus clupeiformis, Mitch.)

By S. A. Forbes.

In a very large lake the conditions of life are remarkably uniform. The volume of water remains, of course, nearly constant from season to season and from year to year, and the extremes of summer heat and winter cold have but a moderate effect upon the temperature of the lake as a whole. Consequently both plant and animal life exhibit there a regularity and stability which are in remarkable contrast to their fluctuations in smaller bodies of water and on the surrounding land. Not only do the relative numbers of individuals in the various species remain about the same, but the absolute number of each must necessarily change but little, as a rule.

Such a state of affairs is eminently favorable to an exact and *economical* balance of supply and demand, of income and expenditure, of multiplication and destruction, among the inhabitants of the lake. Here, every species of animal, whether predaceous or vegetarian, must find, in the surplus products of growth and reproduction among the species upon which it depends for food, a far more constant and unvarying supply for its needs than elsewhere; and the species fed upon must be subject to a far more regular drain upon their surplus numbers or unessential structures. Where there is little fluctuation there is little waste.

A system of life like this, running on with relatively even tenor for centuries, must of course be much less *flexible* than one where wide and violent fluctuation and continual reädjustment are the rule; and a species in any way deeply affected will here have within itself far less recuperative power than one which has been forced again and again — each year, perhaps — to rally against the most destructive attacks as the price of its continued

existence. Disturbances of the natural balance of life, of the primitive and spontaneous system of reäctions by which the different groups of organisms are related, will therefore be unusually serious and lasting; and where such disturbances result from human interference, as by the yearly capture of large numbers of any important fish, it is especially desirable that artificial means of compensation be taken to restore the disturbed balance as nearly as possible. Excessive loss will be made good by natural reäctions far more slowly than if it occurred to a pond or river species, accustomed, as most of the latter are, to fill up rapidly enormous gaps in their numbers.

On the other hand, to multiply *unduly* by artificial measures any species naturally abundant in such a lake, will have scarcely a less disturbing influence than to *diminish* its numbers in the same ratio. The relatively nice balance between the demand for food and food supply which here naturally obtains, is such that an extraordinary increase in a species must soon reäct to diminish greatly its food resources — a fact which will then take effect on the species itself, reducing it below its natural, original level; and if both excessive capture and excessive multiplication go on side by side we shall have this result finally aggravated to an extreme degree.

As fishes are caught before the end of their natural lives, but planted by the fish culturist when young, it is evidently the food of the young which will be first and most seriously affected by over-production. Only a part of the adults, perhaps a small fraction, will live a life of ordinary natural length, many being captured before they have attained even the average size; but a far greater number, perhaps nearly every one, must survive the earliest period and must consequently draw most heavily upon the earliest food resources of the species when these differ from those of the adult.

The above considerations are brought forward here to show the especial importance, to us, of a study of the system of natural interactions by which the animals of our great lakes affect each other, if we would avoid the necessarily injurious consequences of our own interference with the natural order there obtaining, and above all to show the extraordinary value of a knowledge of the food habits and food capital of the *young*. They apply perhaps

more forcibly to the white-fish than to any other species in the lakes; because this is for several reasons the most important purely fresh-water fish of the great lake region, and proves to have a distinctly different food when young from that upon which it is dependent later.

According to the recent census report,* more than twenty-one million pounds of white-fish were taken in the Great Lakes in 1879, valued at over three-quarters of a million of dollars, and representing nearly half the total sum derived from the lake fisheries of all kinds. These fisheries employ over five thousand men, and a fixed capital of one million three hundred and fory-six thousand dollars. When we reflect that this enormous drain upon the number of the species is necessarily, to a considerable extent, an addition to the natural tax levied upon it by its enemies other than man, we see that there must be an artificial supply provided, or the fisheries will gradually fail.

The importance of the knowledge of the food of so valuable a species needs no demonstration, especially when we consider that, consistently with what has been said above, it may not be difficult to overdo the work of propagation.

If the white-fish were to be multiplied indefinitely, without any attention to the character or abundance of its food supply, it would soon reach such a number that it must infringe upon its own food capital, diminish the average number of the animals upon which it depends for subsistence, and so finally indirectly cripple itself. Then the money and labor expended in its culture would be principally lost, and the last state of the species would be worse than the first. An acquaintance with the food of the young is especially necessary, because they are planted by the fish-culturist when, having already absorbed the egg-sac (the supply of food by which they are under natural conditions supported until they have time to scatter themselves widely through the water), they are in a peculiarly helpless condition, unable to wander far in search of subsistence, and compelled to find food speedily or perish. One would say, therefore, that their alimentary resources and habits should be well and thoroughly known, that the range, period and abundance of the organisms upon

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*Census Bulletin No. 261, Sept. 1, 1881.

which they feed should be carefully determined, and that each locality where the young are deposited should be closely searched for the purpose of ascertaining whether their food species occur there at the time in sufficient quantity to prevent immediate starvation.

Previous studies of the food of young fishes of a variety of families, reported in the third Bulletin of this series, had showed that, with exceptions presently to be mentioned, the earliest food of all the families studied consisted almost wholly of various species of Entomostraca and some equally minute and delicate dipterous larvæ. When that paper was prepared, I had, however, no opportunity to study the food of the young of any members of the family Salmonidæ, to which the white-fish belongs, neither could I learn that any such studies had been made by others; and I could only infer the same fact with regard to this family from the general character of the results obtained by the study of the other groups. Even this inference, however, was rendered doubtful by the discovery that the youngest individuals of two of the toothless families (Catostomidæ and Cyprinidæ) were not strictly dependent upon the food elements above mentioned, but were likewise able to draw upon much smaller organisms, namely: the minutest Protozoa and unicellular Algæ; and as the adult white-fish is likewise destitute of teeth, it was not by any means certain that their young would not fall under the latter category. Upon looking up the literature of the subject, I found that although the food of the adult had been very well made out in a general way,* only two items had been published respecting the food of the young. In the report of the United States Fish Commission for 1872–3, an assistant commissioner, Mr. J. W. Milner, made some experiments on young white-fish hatched artificially, supplying them with a number of articles of food, in the hope of finding something suitable for their nourishment.

"A few crawfish," he says, "were procured and pounded to a paste, and small portions put into jar No. 1; the young fish ate it readily. They were fed at night, and the next morning every one of them was found to be dead. Jar No. 2 was supplied with bread-crumbs, and the fish were seen to take small particles in

*Report of the U. S. Fish Commission for 1872–3, pp. 44–46.

their mouths; they did not die so suddenly. Jar No. 3 was supplied witn sweet cream, but no evidence was afforded that the occupants fed upon it. A quantity of rain-water was exposed to the rays of the sun for the purpose of generating minute forms of life, and a teaspoonful was poured into jar No. 4, morning and evening, in the hopes that their proper food was of this character. In jar No. 5 a variety of food was provided, dry fresh beef, milk, boiled potato, and bread. The crumbs of bread and the scrapings from the beef were all that the fish were seen to take into their mouths. They died, one after another, very rapidly, and in a few days all were dead." He further remarks: "This difficulty of procuring a suitable food for the young white-fish has been the experience of the few fish-culturists who have hatched them."

With the hope of ascertaining the natural food of these fishes, a few specimens, representing young captured in the Detroit River, and others from the hatchery, were submitted by Mr. Milner to Mr. S. A. Briggs, a microscopist, of Chicago. Four examples were examined by Mr. Briggs, two from each of the above situations. Those from the hatchery contained nothing whatever, while those from Detroit River contained numerous specimens of two species of Diatomaceæ, viz., *Fragilaria capucina* and *Stephanodiscus niagaræ.* The only fact at that time known would consequently indicate that the earliest food of the species consisted of Diatomaceæ.

The white-fish, as is well known, lays its eggs in the open lake in autumn, the young not appearing until early in the following spring. At this cold and stormy season in the exposed situations where they are to be sought, it is practically impossible to find the young fish; a fact which rendered the study of their earliest food a subject of unusual difficulty. There seemed, in fact, no practicable way to reach satisfactory conclusions upon it except by experiment upon individuals artificially hatched.

In December, 1880, I made an arrangement, through the kindness of Prof. Baird, of the Smithsonian Institution, with Mr. F. N. Clark, superintendent of the U. S. fish hatchery at Northville, Mich., for a supply of young white-fish to be sent me at intervals from the hatchery under his control. The specimens furnished were taken from two lots. The fishes of one lot, hatched January 18, were kept in a tank in the hatchery, where they were supplied

with water from a spring, which had been cooled by exposure to the air in artificial ponds before entering the hatchery, in order to retard the development of the fry. The ordinary range of temperature in the tank, was from thirty-five to thirty-nine degrees. These fishes were fed daily with a paste made by grinding small amphipod crustaceans (Gammarus) in a mortar.

The second lot, hatched January 20, was kept, unfed, in a perforated tin box, in a rivulet flowing from a spring, about sixty feet from its source. The water had a uniform temperature of forty-seven degrees.

Those in the spring being in warmer water than the others, developed much more rapidly, and it was believed that the character and source of this water was such as to furnish them at least a small supply of such food as young fishes are accustomed to appropriate.

Ninety specimens were received from the hatchery February 9, at which time they were three weeks old. They were thirteen mm. (half an inch) in length by one in depth. The egg-sac was but partially absorbed in most of the lot, but in those most advanced was represented by an oil globule back of the head. The pectoral fins were well developed, but no trace of the ventrals had as yet appeared. The single median fin extended well in front of the vent, and forwards on the back nearly to the head. The opercles did not fully cover the gills. The most highly developed specimens — those whose gill-sacs had nearly disappeared — had, at a short distance on either side of the symphysis of the lower jaw, a sharp, strong, raptatorial tooth, curved backwards and slightly inwards. The base of this tooth was very broad, and the point acute and slender. At a point behind each of these teeth about half their distance from each other, was a second much smaller tooth, directed almost exactly inwards. The upper jaw was, however, wholly toothless.

These fishes were all passed under the microscope, after having been rendered transparent, but only four of them contained anything whatever; three a little dirt, and the fourth a minute fragment of the crust of the Gammarus, with which they had been fed.

Of one hundred and eleven specimens received February 17, seventeen had taken food. I dissected nine of these and found

fragments of Gammarus and nothing else. Ninety specimens from the same lot were examined February 25, and food was found in fourteen. Four of these had eaten Gammarus fragments; two, larvæ of gnats; one, a small Cypris, and eight contained small fragments of the leaves and stems of vascular plants, including a bit of a netted-veined leaf and a little piece of pine wood. Thirty-nine specimens, the last of the lot, were received March 15, and food was found in fourteen. I dissected nine of these, finding fragments of Gammarus in four, a larva of a gnat, a Chironomus larva, a larva of some undetermined fly, a minute vegetable fragment, a Cyclops, a Cypris, and an undetermined Entomostracan each in one. Three hundred and forty fry from the hatching house were examined in all, in forty-seven of which (fourteen per cent.) more or less food was discernible. Of the thirty-five dissected, eighteen had eaten Gammarus fragments; five, minute insect larvæ; four, Entomostraca, and eight, small particles of vegetation.

Only four lots were received from the spring, on the 9th, 14th, 17th, and 25th of February, after which all died of starvation. In the first hundred only one was found which had taken food, and this had eaten a trace of filamentous Algæ and a minute fragment of the parenchyma of some higher plant, with a few diatoms. But one of the second hundred contained even a trace of food, a minute quantity of some thread-like Alga, the cells of which still contained a little chlorophyll. In the third hundred likewise, food was found in but one. This consisted of a few particles of vegetable parenchyma, doubtless derived from the decaying plant structure in or around the water. In the third lot of only forty-two specimens, six showed traces of food, consisting almost entirely of a few filamentous Algæ (including a fragment of Oscillatoria) and a little vegetable parenchyma. Desmids and diatoms were observed in trivial numbers.

The total number received from the spring was two hundred and forty-two, of which but eight were found to have eaten anything (a little over three per cent. of the whole), and these had taken only Algæ and vegetable fragments.

An example of the water of the spring sent me contained many Algæ but no animals larger than rotifers. The water of the hatchery, being exposed in ponds of considerable size, afforded a

better opportunity for the development of animal life, to which fact was doubtless due the occurrence of insect larvæ and Entomostraca in the intestines of the fishes reared in it. The situation of the spring, on the other hand, was particularly unfavorable, as it was under the hatchery, and consequently in the dark.

The observations above described on the specimens kept in spring water, have but little value for the reason that evidently very little food was contained in the water flowing through their cage. The vegetation in the streams being chiefly filamentous Algæ and the number of Entomostraca apparently trivial, very little of either vegetable or animal food could reach the little prisoners. It is not surprising, therefore, that notwithstanding their greater age and the higher temperature of the water in which they were kept, a much smaller ratio of the specimens had taken food than of those captured in the hatchery. From the contents of their intestines we can only infer that these fishes, reduced to a desperate strait by starvation, will snatch at almost anything contained in the water. The result obtained by a study of those from the hatching house was more significant, but still unsatisfactory. It seemed to indicate that in confinement white-fish fry will feed upon both animal and vegetable structures to some extent, and that they can be induced to take minute fragments of the higher crustaceans, but not in sufficient quantity to keep them alive. The fact that animal food was more abundant than vegetable in this last lot, indicates nothing of their natural preference, since it was doubtless also more abundant in the water containing them.

More light was thrown upon the earliest food habits of these fishes by the discovery of raptatorial teeth upon the lower jaw, than by these dissections of their alimentary canals. All the families of fishes which I had previously studied whose young were provided with teeth were found strictly dependent at first upon Entomostraca and the minuter insect larvæ; while only those whose young were toothless fed to any considerable extent upon other forms. The discovery of teeth in the young white-fish, therefore, placed this species definately in the group of those carnivorous when young. The fact that the adult was itself toothless interfered in no way with this inference, because other toothless fishes (Dorsoma) whose young were furnished with teeth, had been found carnivorous at an early age.

The inconclusive character of the results thus far obtained, made it necessary to attempt to imitate more closely the natural conditions of the young when hatched in the lake. In February, 1881, I obtained, through the kindness of Mr. Clarke, twenty-five specimens of living young white-fish, saved from a lot which he was planting in the waters of Lake Michigan, off Racine, Wisconsin. I succeeded in conveying these to the laboratory without loss, and there kept them for several days in a glass aquarium and supplied them with an abundance of the living objects to be obtained by drawing a fine muslin net through the stagnant pools of the vicinity. These consisted of many diatoms and filamentous fresh-water Algæ, of two or three species of Cyclops, of *Canthocamptus illinoisensis*, and *Diaptomus sanguineus* among the Copepoda, and of two rather large Cladocera, *Simocephalus vetulus* and *S. americanus.* These little fishes were kept under careful observation for several days, the water in the aquarium being frequently aërated by pouring. Many of them had, however, been injured by handling, and eleven of the specimens died without taking food. It was soon evident that the larger Entomostraca (the Simocephalus, and even the Diaptomus), were quite beyond the size and strength of these little fishes, and that only the smaller Copepoda among the animals available, could afford them any food at first. These they followed about from the beginning with signs of peculiar interest, occasionally making irresolute attempts to capture them. Two days after their arrival, one of the young white-fish had evidently taken food, which proved, on dissection, to be a small Cyclops. During the next two days nine others began to eat, dividing their attentions between the Cyclops above mentioned and the Canthocamptus, and on the 22d two others took a Cyclops each and a third a Canthocamptus. One of these fishes contained still a large remnant of the egg-sac, showing that the propensity to capture prey must antedate the sensation of hunger. On the 25th the fourteenth and last remaining fish captured its Cyclops and was itself sacrificed in turn. As an indication of the efficiency of the raptatorial teeth, it may be worth while to note that I saw one of the smallest fishes make a spring at a Cyclops, catch it, give three or four violent wriggles, and drop it dead to the bottom of tank.

As a general statement of the result of the observations made

on these fourteen fishes, we may say that eight of them ate a single Cyclops each, that one took two, and another three of the same, that one took a single Canthocamptus, that two specimens captured two each of this genus, and that finally, a single fish ate Cyclops and Canthocamptus both. The final conclusion was a highly probable inference that the smallest Entomostraca occurring in the lake would prove to be the natural first food of the species.

In order to test this conclusion with precision, I arranged a similar experiment on a larger scale and under more natural conditions. Through the generosity of the Exposition company, of Chicago, I was allowed the use of one of the large aquarium tanks in the exposition building on the lake shore, and by the repeated kindness of Mr. Clarke, of Northville, Michigan, I was furnished with a much larger number of living white-fish. Five thousand fry were shipped to me in a can of water, but through unfortunate delays in changing cars at intermediate points, about two-thirds of these were dead when they reached my hands. Those living were immediately transferred to the tank, through which the water, taken from the city pipes, had already been allowed to run for several hours. As this water is derived from Lake Michigan at a distance of two miles from the shore, and had at this time the exact temperature of the open lake, the conditions for experiment were as favorable as artificial arrangements could well be made.

Sending a man with a towing net out upon the lake with a boat, or upon the remotest breakwaters, immense numbers of all organic objects in the water were easily obtained. After enclosing the exit of the tank with a fine wire screen, to prevent the escape of objects placed in it, we poured these collections of all descriptions indiscriminately into the water from day to day, thus keeping the fishes profusely supplied with all the various kinds of food which could possibly be accessible to them in their native haunts. From this tank one hundred fishes were taken daily and placed in alcohol for dissection and microscopic study, to determine precisely the objects preferred by them for food. These were examined at a later date, and all contents of the intestines were mounted entire as microscopic slides, and pemanently preserved. A careful study, was of course made of the organisms of the lake, as shown by the product of the towing net, and when the experi-

ment was finally ended, an equally careful examination followed of the living contents of the water of the tank at that time.

These fishes, like those previously described, had already reached the age and condition at which it is customary to "plant" them in the lake. The ventrals were still undeveloped, the egg-sac had nearly disappeared, the four mandibular teeth were present, and the median fin extended from the tips of the pectorals on the belly to a point opposite the middle of the same fins on the back. In most the egg-sac did not protrude externally, being reduced in some to a droplet of oil, but remaining in a few of a size at least as great as that of the head. The alimentary canal was of course a simple straight tube, without any distinction of stomach and intestine.

The sufferings of these fry in transit had doubtless weakened the vitality of the survivors, and although every care was taken to keep the water of the tank fresh and pure, about one-third of those remaining died during the progress of the experiment. The aquarium in which they were confined was built of glass, and had a capacity of about one hundred cubic feet. The temperature, tried repeatedly, stood at forty-two degrees Fah. A steady current of the water of the lake was maintained through this tank, entering through a rose, from which it fell in a spray, thus insuring perfect aëration.

By far the greater part of the organic contents of the water of the lake, as shown by the product of the towing net, consisted of diatoms in immense variety, which formed always a greenish mucilaginous coating upon the interior of the muslin net. In this were entangled, a variety of rotifers, occasional filamentous Algæ, and many Entomostraca, the latter belonging chiefly to the genera Cyclops, Diaptomus, and Limnocalanus among the Copepoda, and to Daphnia among the Cladocera.

As the Entomostraca proved to be far the most important elements of this food supply, the particulars respecting them may be properly more fully given. The smallest of all was a Cyclops, then new, but since described by me under the name of *Cyclops thomasi.** This little Entomostracan is only .04 inch long, by .011

*On some Entomostraca of Lake Michigan and Adjacent Waters. American Naturalist, Vol. XVI., No. VIII, August, 1882, pp. 640 and 649.

wide. The next in size, and by far the most abundant member of this group was a Diaptomus, likewise new, described in the paper just cited under the name of *Diaptomus sicilis.* This appears in two forms, one evidently young in the stage just preceding the adult. Full grown individuals were .065 inch long, by one-fourth that depth. The Limnocalanus was a much larger form, evidently preying, to a considerable extent, upon the two just mentioned. All the Cladocera noticed were *Daphnia hyalina*, an elegant and extremely transparent species, occurring likewise in the lakes of Europe. A single insect larval form (Chironomus) should likewise be mentioned in this connection, since it had about the same size and consistence of the Entomostraca, and was consequently equally available for food.

The specimens of each of the above species from a certain quantity of these collections were counted, in order to give a definite idea of their relative abundance in the lake. The Diaptomus numbered 225, the Cyclops 75, Limnocalanus 7, Daphnia 3, and Chironomus larvæ 1. It was a curious fact, however, that when the water was drawn off at the end of the experiment, more than half the Entomostraca were Limnocalanus; a fact partly to be explained by the predaceous habit of the latter, and partly by the facts relating to the food of the fishes themselves, which are presently to be detailed.

The fry were placed in the tank and supplied with their first food on the evening of the 12th of March. On the 14th, one hundred specimens were removed, and twenty-seven of these were dissected. Twenty were empty, but the remaining seven had already taken food, all Cyclops or Diaptomus. Three had eaten Cyclops only, and six Diaptomus, while two had eaten both. Fourteen of these Entomostraca, seven of each genus, were taken by these seven fishes. From those captured the next day, twenty-five specimens were examined, of which nineteen were without food. Of the remaining six, three had eaten Diaptomus and three Cyclops; five of the former being taken in all, and ten of the latter. Three specimens were next examined from those caught on the 19th of March, two of which had devoured Diaptomus, and a third a single *Cyclops thomasi* and a shelled rotifer, *Anuræa striata.* The character of the food at these earliest stages was so well settled by these observations that I deemed it unnecessary to exam-

ine the subsequent lots in detail, but passed at once to the specimens taken on the 23d. Twenty-six of these were examined, and found to have eaten thirty-three individuals of *Cyclops thomasi*, fourteen of *Diaptomus sicilis*, and fourteen of the minute rotifer already mentioned (*Anuræa striata*). Two had taken a few diatoms (*Bacillaria*) and one had eaten a filament of an Alga. Cyclops was found in sixteen of the specimens, Diaptomus in nine, and Anuræa in eight, only two of them being empty. The amount of food now taken by individual fishes was much greater than before, one specimen dissected having eaten two Cyclops and six *Diaptomus sicilis*, male and female. Another had taken five Cyclops, one Diaptomus and five examples of *Anuræa striata*. Still another had eaten four of the Cyclops, four Diaptomus, and one Anuræa.

Twenty-five specimens were examined from those removed on the 24th of the month, at which time the water of the tank was drawn off and all the remaining fishes bottled. Four of these had not eaten, but the twenty-one others had devoured fifty specimens of *Diaptomus sicilis*, forty-seven of *Cyclops thomasi*, fourteen of *Anuræa striata*, and a single *Daphnia hyalina*, the latter being the largest object eaten by any of the fishes. A few examples of their capacity may well be given. The ninth example had eaten six Diaptomus, two *Cyclops thomasi* and one Anuræa; the tenth had taken eight Diaptomus, two Cyclops and an Anuræa; and the twentieth, seven Diaptomus and three *Cyclops thomasi*. In two of these examples were small clusters of orange globules, probably representing unicellular Algæ.

Summarizing these data briefly, we find that of the 106 specimens dissected, sixty-three had taken food, and that the ratio of those which were eating increased rapidly, the longer the fishes were kept in the aquarium. Only one-fourth of those examined on the fourteenth of the month had taken food, while more than five-sixths of those bottled ten days later had already eaten. The entire number of objects appropriated by these sixty-three fishes was as follows: *Cyclops thomasi*, ninety-seven; *Diaptomus sicilis*, seventy-eight; *Anuræa striata*, twenty-nine; *Daphnia hyalina*, one. Seven of the fishes had eaten unicellular Algæ, two had eaten diatoms, and one, filamentous Algæ.

From the above data we are compelled to conclude that the earliest food of the white-fish consists almost wholly of the smallest species of Entomostraca occurring in the lake, since the other elements in their alimentary canals were evidently either taken accidentally, or else appeared in such trivial quantity as to contribute nothing of importance to their support. In fact, two species of Copepoda, *Cyclops thomasi* and *Diaptomus sicilis*, are certainly very much more important to the maintenance of the white-fish in this earliest stage of independent life than all the other organisms in the lake combined. As the fishes increase in size, vigor, and activity, they doubtless enlarge their regimen by capturing larger species of Entomostraca, especially Daphnia and Limnocalanus.

A few words respecting the relative abundance of these species at different seasons of the year and their distribution in the lake, will have some practical value. We may observe here an excellent illustration of the remarkable uniformity of the life of the lake as contrasted with that of smaller bodies of water already referred to, in the introduction to this paper. While in ponds minute animal life is largely destroyed or suspended during the winter, the opening spring being attended by an enormous increase in numbers and rate of multiplication, in Lake Michigan there is but little difference in the products of the collecting apparatus at different seasons of the year.* There is a slight increase in the number of individuals during spring and early summer, but scarcely enough appreciably to affect the food supply of fishes dependent upon them. They are not by any means equally distributed, however, throughout the lake, my own observations tending to show that there are relatively very few of these minute crustaceans to be found at a distance of a few miles from shore, and that in fact by far the greater part of them usually occur within a distance of two or three miles out. Indeed, the mouths of the rivers flowing into the lake are ordinarily much

*For definite assurance of this fact, I am indebted less to my own observations (which are, however, consistent with it as far as they go) than to the statements of B. W. Thomas, Esq., of Chicago, who, while making a specialty of the Diatomaceæ of the lake, has collected and studied all its organic forms for several years, obtaining them from the city water by attaching a strainer to a hydrant many times during every month throughout the year.

more densely populated by these animals than the lake itself, as has been particularly evident at Racine and South Chicago. Neither are they commonly equally distributed throughout the waters in which they are most abundant, but like most other aquatic animals, occur in shoals. In the deeper portions of the lake, many species shift their level accordiug to the time of day, coming to the surface by night, and sinking again when the sun is bright.

These facts make it important to the fish-culturist that the particular situation where it is proposed to plant the fry should be searched at the time when these are to be liberated, to determine whether they will find at once sufficient food for their support. A little experience will easily enable one to estimate the relative abundance of the Entomostraca at any given time and place, and they require nothing for their capture more complicated or difficult of management than a simple ring net of cheese-cloth or similar material, towed behind a boat. This may be weighted and sunk to any desired depth, so that the contents of the water either at the surface or at the bottom, may be ascertained by a few minutes' rowing.

In conclusion, I wish again to express my great obligation to the United States Fish Commissioner, Prof. S. F. Baird, and to Frank N. Clark, Superintendent of the United States Hatchery at Northville, Mich., through whom, as already stated, the specimens were derived upon which these studies were made. My best thanks are also due to the Exposition company of Chicago, and especially to their secretary, the Hon. John P. Reynolds, for the use of a tank in the Exposition building, and for many courtesies received while the experiment there was in progress.

ERRATA.

Page 6, line 12 from bottom; page 8, line 15; page 11, line 2; for *Cydnidæ*, read *Pentatomidæ.*

Page 17, line 9, before *Vireo*, omit *and.*

Page 23, above ARACHNIDA, for *Cydnidæ*, read *Pentatomidæ.*

Pages 25 and 27, above *Orthoptera*, for *Cydnidæ*, read *Pentatomidæ.*

Page 28, lines 2 and 8, for *Graphorhinus vadosus*, read *Epicærus imbricatus.*

Page 64, under *Hemiptera*, for *Siphonophora granariæ*, read *Aphis maidis.*

Page 69, line 5 from bottom, for *fresh-water*, read *local.*

Page 78, line 1, after *all*, insert *the.*

Page 82, line 7, for *character*, read *characters.*

Page 91, line 5, for *consisted*, read *consists.*

Page 92, line 2 from bottom, for *more*, read *most.*

Page 97, line 11, for *fory-six*, read *forty-six.*

Page 99, line 2, for *witn*, read *with.*

Page 101, lines 12 and 13 from bottom, for *structure*, read *structures.*

Page 105, line 23, for *aération*, read *aëration.*

Pages 1 *to* 16 *of this Bulletin were printed Oct.* 18 ; *pp.* 17 *to* 32, *Dec.* 16 ; *pp.* 33 *to* 40, *Dec.* 19 ; *pp.* 41 *to* 48, *Dec.* 20 ; *pp.* 49 *to* 56, *Dec.* 21 ; *pp.* 57 *to* 72, *Dec.* 29.

W. O. DAVIS, Printer.